NASA Reference Publication 1063

Bibliography of Supersonic Cruise Research (SCR) Program From 1977 to Mid-1980

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DECEMBER 1980

NASA

NASA Reference Publication 1063

Bibliography of Supersonic Cruise Research (SCR) Program From 1977 to Mid-1980

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National Aeronautics
and Space Administration

**Scientific and Technical
Information Branch**

1980

CONTENTS

Page

INTRODUCTION

The Supersonic Cruise Research (SCR) Program was initiated in July 1972 by the National Aeronautics and Space Administration. Originally, the program was entitled Advanced Supersonic Technology (AST); this was later changed to Supersonic Cruise Aircraft Research (SCAR) and, more recently, to SCR. However, the overall objectives are essentially the same and may be summarized as follows:

1. To provide an expanded technology base for future civil and military supersonic aircraft
2. To provide the data needed to assess environmental and economic impacts on the United States of present and future supersonic transport aircraft
3. To define the potential benefits and trade-offs of advancements in aerodynamic efficiency, structures and materials, propulsion systems, and stability and control methods applied to promising advanced supersonic cruise aircraft concepts

This program included system studies and the following disciplines:

Propulsion
Stratospheric emission impact
Structures and materials
Aerodynamic performance
Stability and control

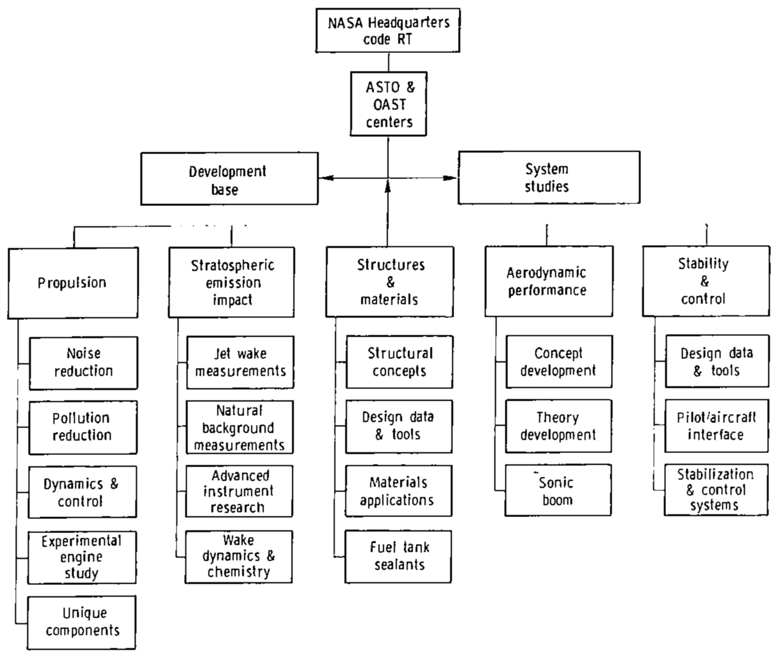
In a coordinated effort to provide a sound basis for any future consideration that may be given by the United States to the development of an acceptable commercial supersonic transport, integration of the technical disciplines was undertaken, analytical tools were developed, and wind-tunnel, flight, and laboratory investigations were conducted.

SCR Management

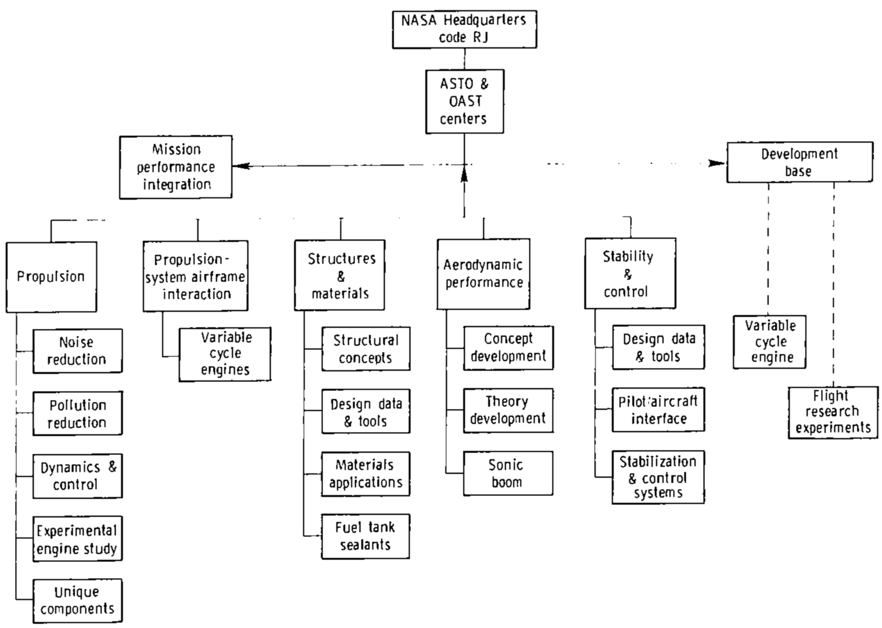
The SCR Program is managed by the Office of Aeronautics and Space Technology (OAST), Aeronautical Systems Division (Code RJ), High Speed Aircraft Systems Technology with the Langley Research Center designated as the lead center. The Advanced Supersonic Technology (AST) Office was established at Langley for technical management and coordination of the program. The Ames Research Center, the Lewis Research Center, the Dryden Flight Research Center, and the Jet Propulsion Laboratry, in addition to the Langley Research Center, implement the program through contracts with the aircraft industry, research grants to universities, and in-house experimental and analytical work.

Program Structure

A block diagram showing the initial organization of the program in fiscal year 1973 is shown in figure 1(a). As progress was made during the first 7 years of work, the program structure gradually changed to that shown in figure 1(b). The major disciplines (namely, propulsion, structures and materials, aerodynamic performance, and stability and control) plus systems studies remained essentially the same. Stratospheric emission impact was absorbed into propulsion, and a new discipline which addressed propulsion-systems/airframe interaction



(a) Fiscal year 1973.



(b) Fiscal year 1979.

Figure 1.- SCR Program structure.

was initiated in fiscal year 1978. The Variable Cycle Engine Component Program and the flight research experiments shown in figure 1(b) are other OAST programs which provide technology data for the SCR development base. The relative level of effort expended for each discipline from fiscal year 1973 to fiscal year 1980 is presented in figure 2.

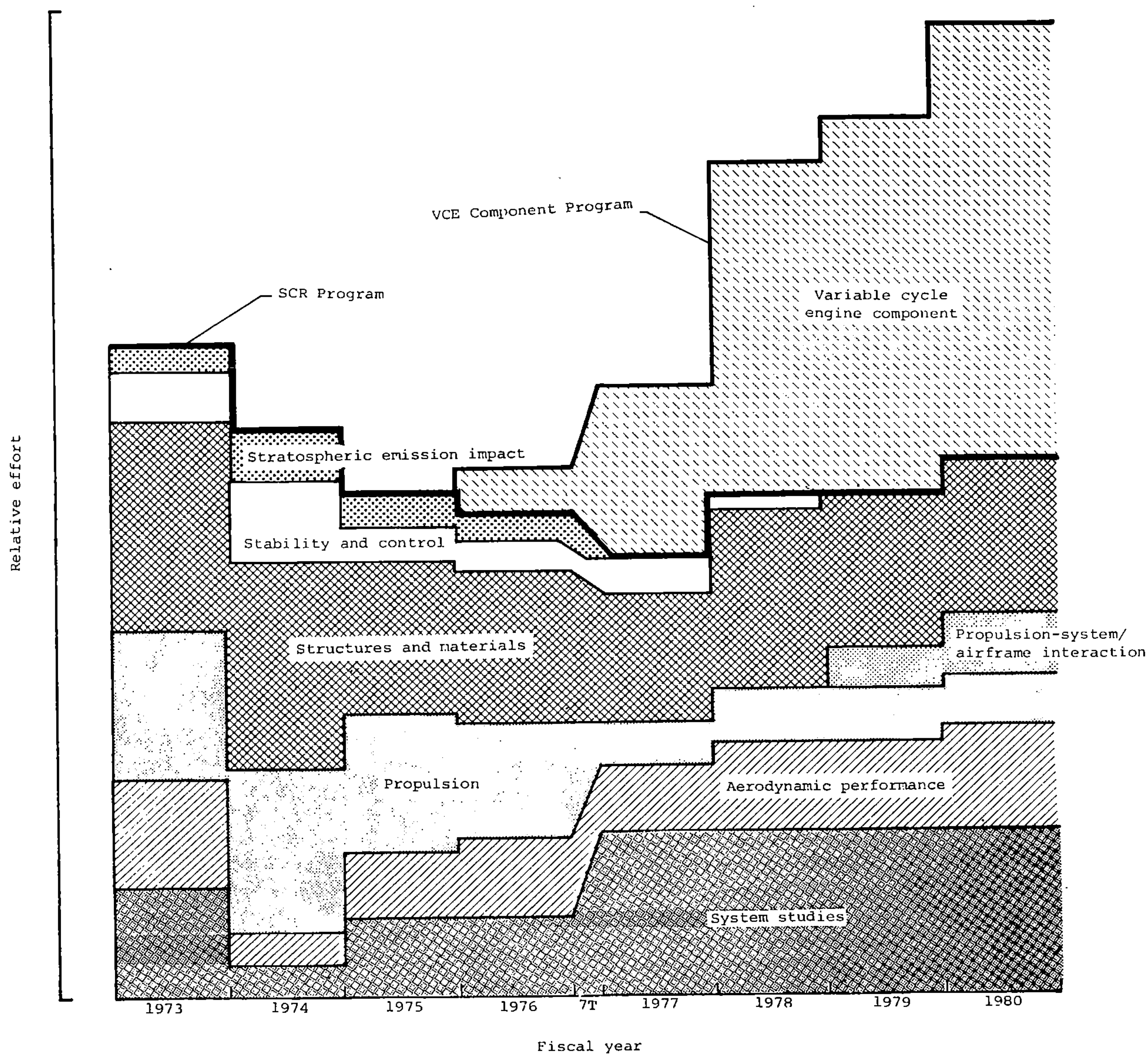


Figure 2.- Relative effort expended on SCR disciplines.

SPECIFIC OBJECTIVES

System Studies

The specific objectives for system studies are

- To identify and assess the impact of new technologies applicable to future supersonic commercial aircraft
- To determine how these technologies can be successfully integrated into a design for a supersonic cruise aircraft; in particular, investigate such areas as subsonic and supersonic performance, economics, safety, comfort, and those characteristics (e.g., noise, pollution) which interact with the social community
- To perform arrow wing feasibility studies, from primary structural design to flexibility effects, in order to assist in defining aerodynamic configurations which will advance arrow wing structural designs

Propulsion

The specific objectives for propulsion are

- To acquire performance data for engine cycles suitable for an advanced supersonic transport
- To reduce engine noise
- To provide technology for a turbine engine combustor with reduced nitric oxide emissions at supersonic cruise conditions
- To provide experimental verification of the facts of upper atmosphere pollution
- To develop and test an integrated inlet/engine control system
- To develop advanced materials for applicable engines
- To provide an advanced experimental engine so that a complete system is available for examining the interactions of components and for determining the overall performance and operating characteristics
- To develop a complete data base on coannular jet noise suppression at forward velocity conditions
- To experimentally verify the performance and development risks of selected engine components such as composite blades, internal valving, supersonic fans, and stowable suppressors
- To conduct sensitivity trade-offs to optimize engine cycle variability features to provide enhanced system performance, improved economics, and environmental compliance

Propulsion-System/Airframe Interaction

The specific objectives for propulsion-system/airframe interaction are

- To generate a necessary engine/airframe installation data base and use it in development of design procedures and methodology for the optimized installation of multiengine propulsion systems on advanced supersonic cruise aircraft
- To develop a data base on inlet and nozzle configurations for variable cycle and suppressed jet engines applicable to supersonic cruise aircraft

- To evolve and apply methodologies for optimization of the propulsion-system installation on advanced aircraft of this class operating over wide variations in speed
- To evolve and demonstrate integrated propulsion-system/aircraft control systems required to achieve and maintain nominal aircraft design performance and environmental compliance
- To continuously analyze and evaluate the influence of engine cycle variations and engine component performance on aircraft operations, economics, and environmental compatibility

Stratospheric Emission Impact

The specific objectives for stratospheric emission impact are

- To determine the composition of the jet wake and perturbations (chemical and hydrodynamic) in the stratosphere that are caused by the passage of supersonic aircraft
- To develop and apply advanced instrumentation to measure the trace constituents in the stratosphere
- To develop techniques to analyze and describe the possible detrimental effects on the natural stratosphere of exhaust systems from fleets of supersonic aircraft

Structures and Materials

The specific objectives for structures and materials are

- To evaluate new metallic materials, composites, and composite reinforced metals for potential use in an advanced supersonic transport
- To design, fabricate, and test under appropriate loading and environmental conditions typical structural elements and components that are fabricated from advanced materials, with particular emphasis on fatigue and fracture tests
- To assess the relative merits of advanced structural concepts and demonstrate the effectiveness of these concepts by construction and test of major assemblies
- To develop the analytical techniques and design methods for advanced arrow wings
- To develop and evaluate analytical techniques for predicting flight effects, ground load effects, and aeroelastic effects
- To fully explore the potential of superplastic-forming/diffusion-bonding (SPF/DB) of titanium
- To evaluate and document a family of composite materials for high-temperature applications

Aerodynamic Performance

The specific objectives for aerodynamic performance are

- To develop preliminary designs of promising supersonic configuration concepts based on the application of control configured vehicle (CCV) and low sonic boom technology
- To optimize an arrow wing configuration which would have high aerodynamic efficiency in supersonic cruise and satisfactory low-speed characteristics

- To develop rational stability and control power criteria to be applied to proposed configuration concepts
- To develop and validate methods of predicting low-speed and high-speed aerodynamic characteristics for both design and off-design flight conditions
- To incorporate the new methods into computerized design tools in order to provide the aircraft designer with the means to accurately and rapidly accomplish the design trade-offs necessary for an efficient transport
- To conduct sonic boom simulations to obtain subjective response data and thereby establish criteria for sonic boom exposure characteristics that are acceptable to the public
- To fully validate in wind-tunnel tests candidate configurations at appropriate flight speed conditions

Stability and Control

The specific objectives for stability and control are

- To develop an improved data base for the design of aerodynamic control surfaces
- To conduct piloted simulation studies for the determination of handling qualities criteria for advanced CCV supersonic transports
- To determine failure modes to alternative redundant control system mechanizations and the ability of the pilot to react to these failures
- To predict the effect of aeroelasticity on airplane flight characteristics
- To develop control laws applicable to active control concepts
- To establish the feasibility of wind-tunnel simulation of active control concepts
- To develop improved control systems to cope with interactions between the airframe and propulsion systems
- To develop, through ground-based simulations and flight tests, criteria and control systems for automatic noise abatement procedures.

DISCUSSION

The Supersonic Cruise (Aircraft) Research Program has made continuous and significant progress in all the disciplines since its beginning in July 1972. The program has provided an accelerated and focused technology effort for future commercial supersonic transports in three main areas: concept development, design data and tools, and applications. New problems have been defined and work has been initiated on them within the constraints of the program. In order to keep the technical community informed of this progress, two conferences were held to date and the proceedings published as NASA CP-001, 1977, and NASA CP-2108, 1979. The conference presentations only highlight the progress and one must turn to the more technical documents for details. All the NASA formal reports, articles, presentations, and contractor reports on record at the AST Office at mid-1980 are listed in a previous bibliography, NASA RP-1003, 1977, or are listed in the present one. All of the progress made over the last 7 years cannot be summarized here; however, the reader might be interested in some of the more significant advances.

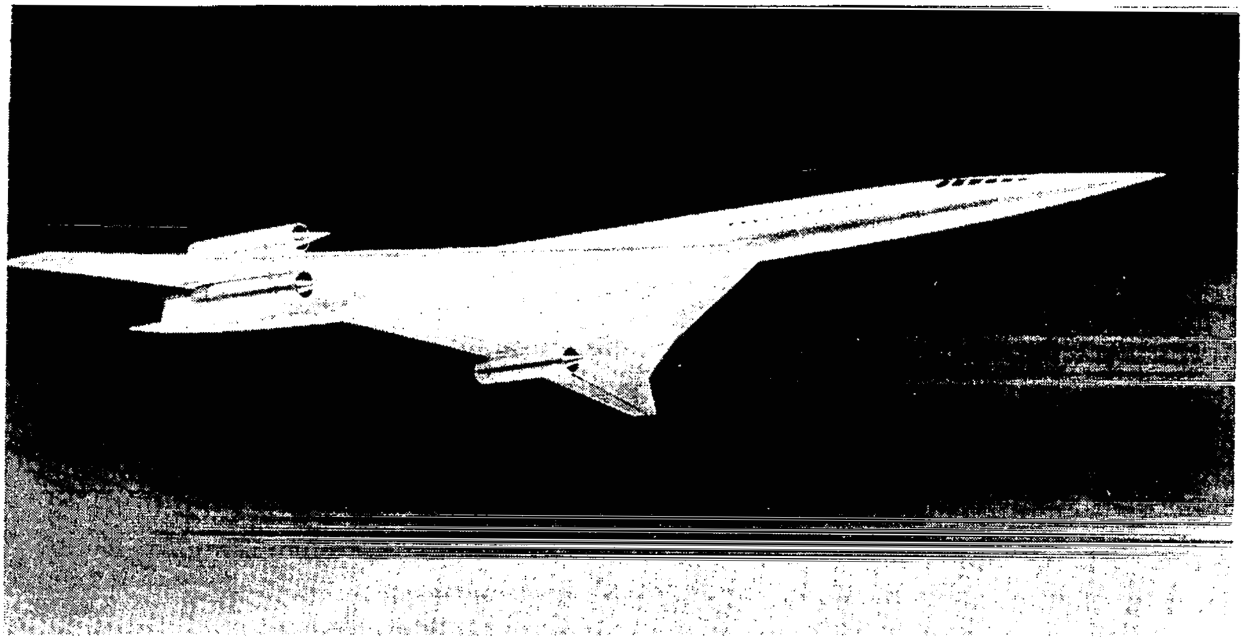
In the area of structural analysis and design, computational procedures are available now to quickly design a vehicle structure that meets the requirements for strength, divergence, and flutter with active controls included. Methods are provided for sizing thermally stressed structures including those containing laminates. Increased emphasis has been given to titanium structure technology, particularly the SPF/DB process. Significant accomplishments have been reported in unsteady aerodynamics, measurement of atmospheric turbulence, aircraft landing loads, temperature capabilities of composites, graphite-polyimide composite applications, and fuel tank sealants.

In aerodynamics, considerable effort has been expended in the past few years to minimize the effects of leading-edge flow separation and vortices on performance, stability, and control. Leading-edge flap deflection concepts to reduce this problem have been studied in detail. Predicted cruise lift-to-drag ratios, improved wing-body blending, and nacelle integration methods to reduce interference have been verified by high-speed wind-tunnel tests.

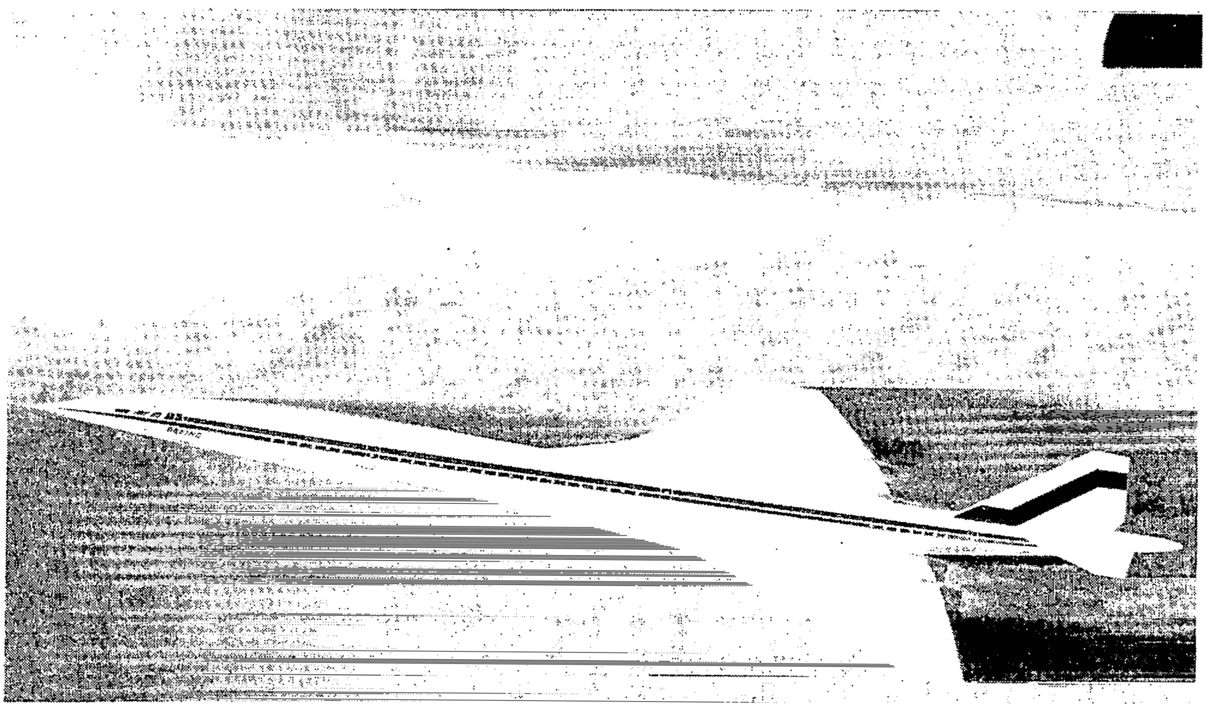
The major effort under stability and control was to expand the relatively small data base on handling quality criteria to aid the certification process for advanced supersonic cruise aircraft. Criteria studies addressed specific failures, approach to dangerous flight conditions, flight at high angles of attack, longitudinal and lateral-directional stability and control requirements, and the primary and secondary control system failure states. The large forward displacement of the crew was found to affect design criteria during maneuvers. Design concepts to improve the inherently poor stability and control features of the configuration and the difficulty of flying ideal flight profiles for community noise abatement, the degree of stability augmentation required, and the need for pilot information displays were investigated with both in-flight simulations and piloted moving base or fixed base simulations. The effect of aeroelasticity on flying qualities for large flexible supersonic aircraft was identified as a problem.

The propulsion studies were supported by both the SCR Program and the Variable Cycle Engine (VCE) Component Program. Large-scale experiments were initiated to investigate critical components of double bypass engines, variable stream control engines, fixed cycle turbofan engines, and other candidates. Noteworthy progress was made on coannular nozzle suppressors (on test beds) and inlets for these types of engines. Satisfying noise and emission constraints without unduly penalizing airplane performance and economics continued to be a major challenge. Studies of the influence of propulsion-system cycle selection and installation and power/flight-path optimization on environmental factors were made. New studies were started on alternate fuels and synthetic fuels.

The system studies provided an opportunity to integrate the newly identified technologies, in all disciplines, into advanced supersonic transport concepts. The trends indicate commercial transports capable of carrying 330 passengers over the Atlantic Ocean or 220 passengers over the Pacific at cruise Mach numbers between 2.2 and 2.7. In order to help the reader visualize the typical subject material of this bibliography, a number of illustrations are presented in figure 3.

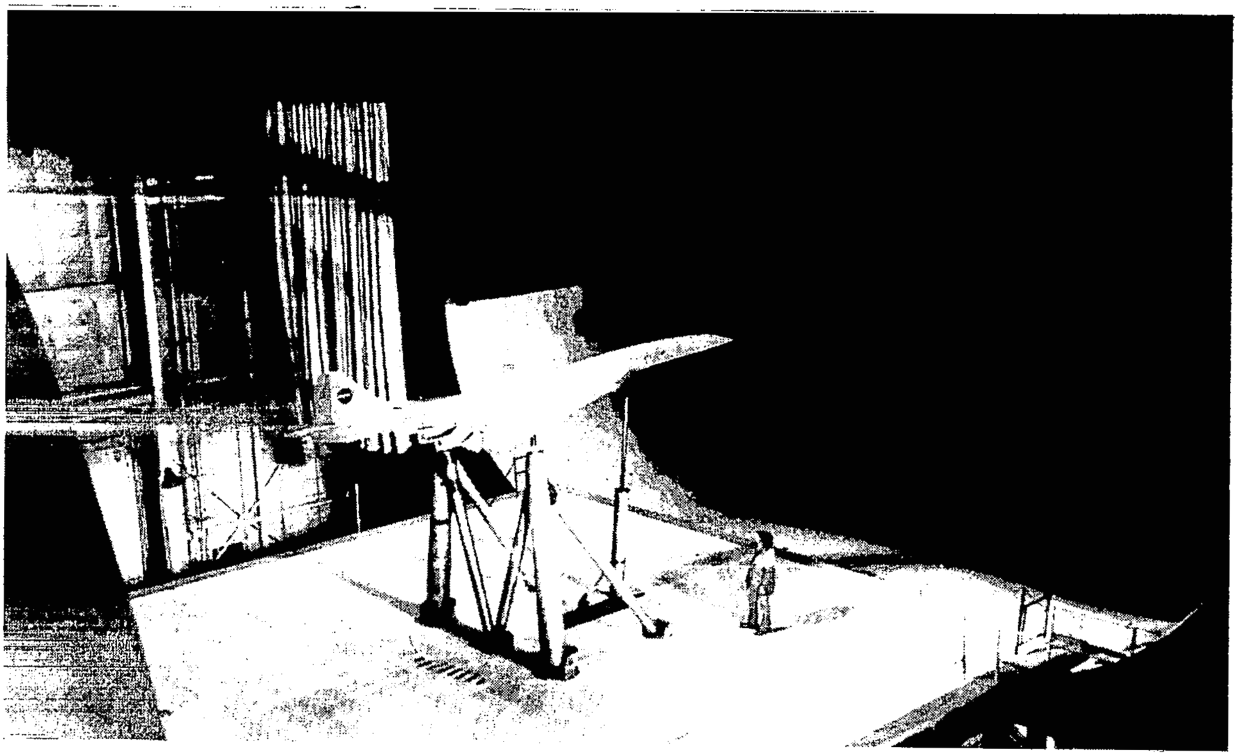


(a) A system-study arrow-wing transport concept.



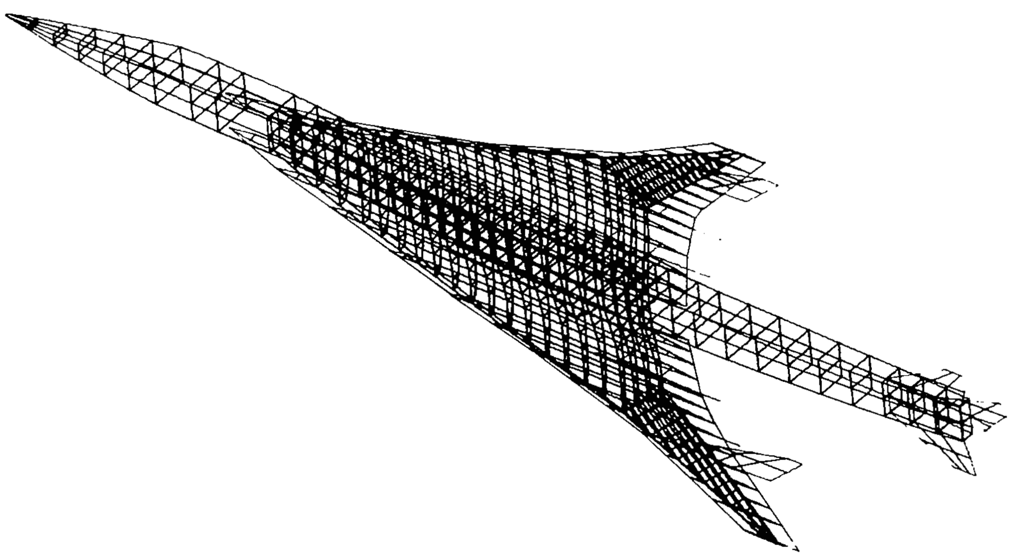
(b) A system-study delta-wing transport concept.

Figure 3.- Examples of advanced supersonic technology studies.



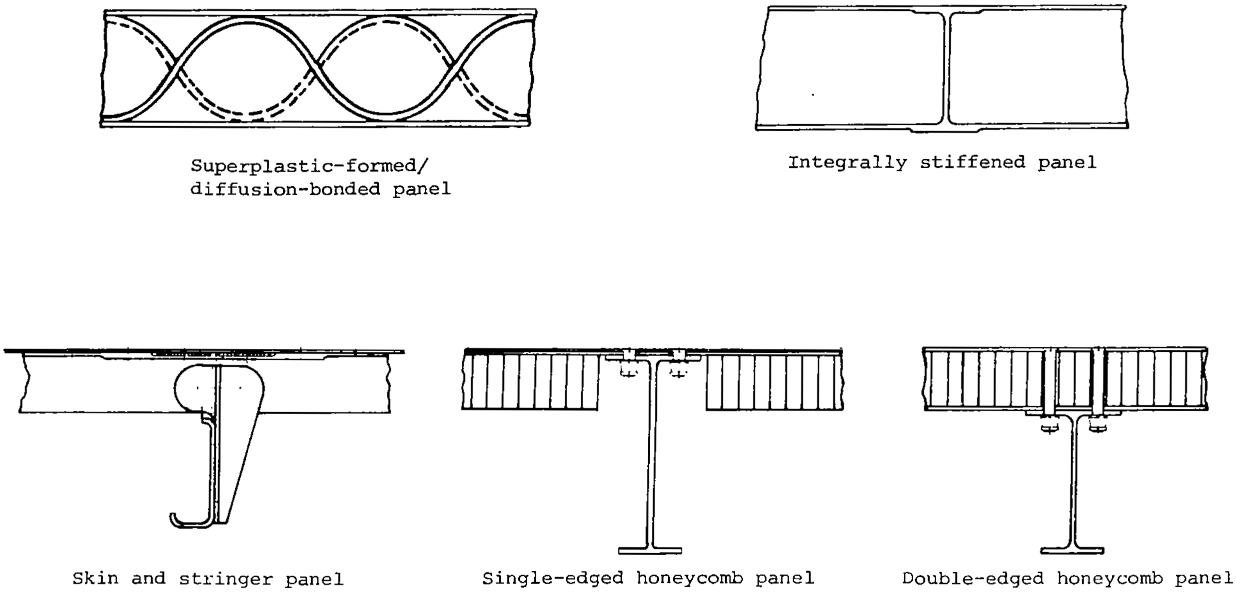
(c) Large model in low-speed wind tunnel.

ADVANCED METHODS

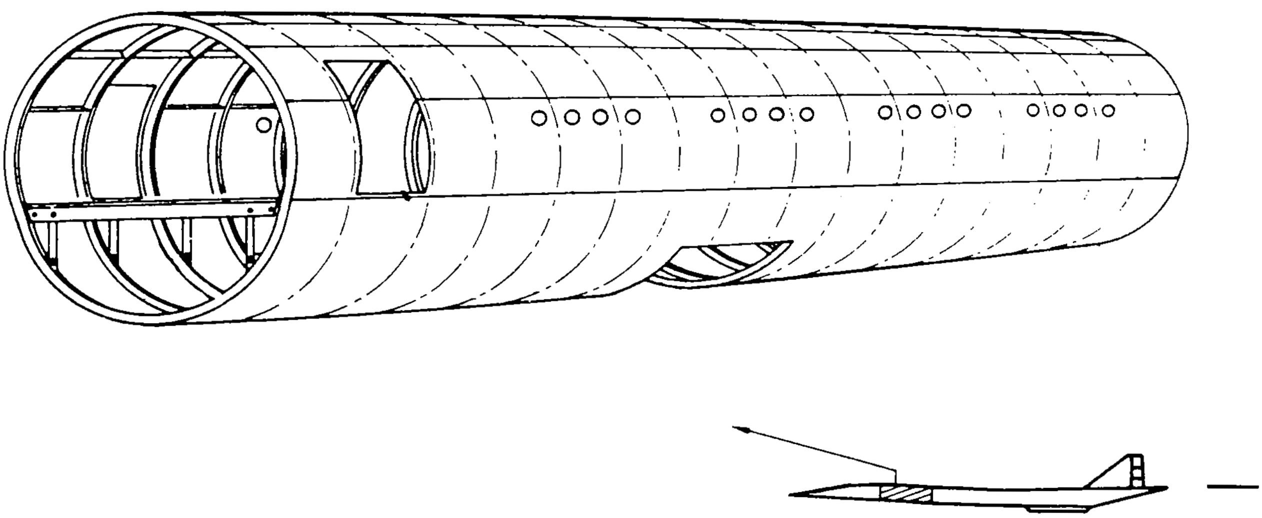


(d) Finite-element model for structural analysis.

Figure 3.- Continued.

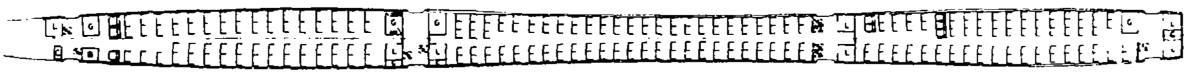


(e) Structural panel concepts.

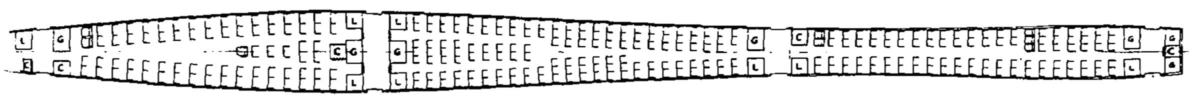


(f) Layout for fuselage study.

Figure 3.- Continued.

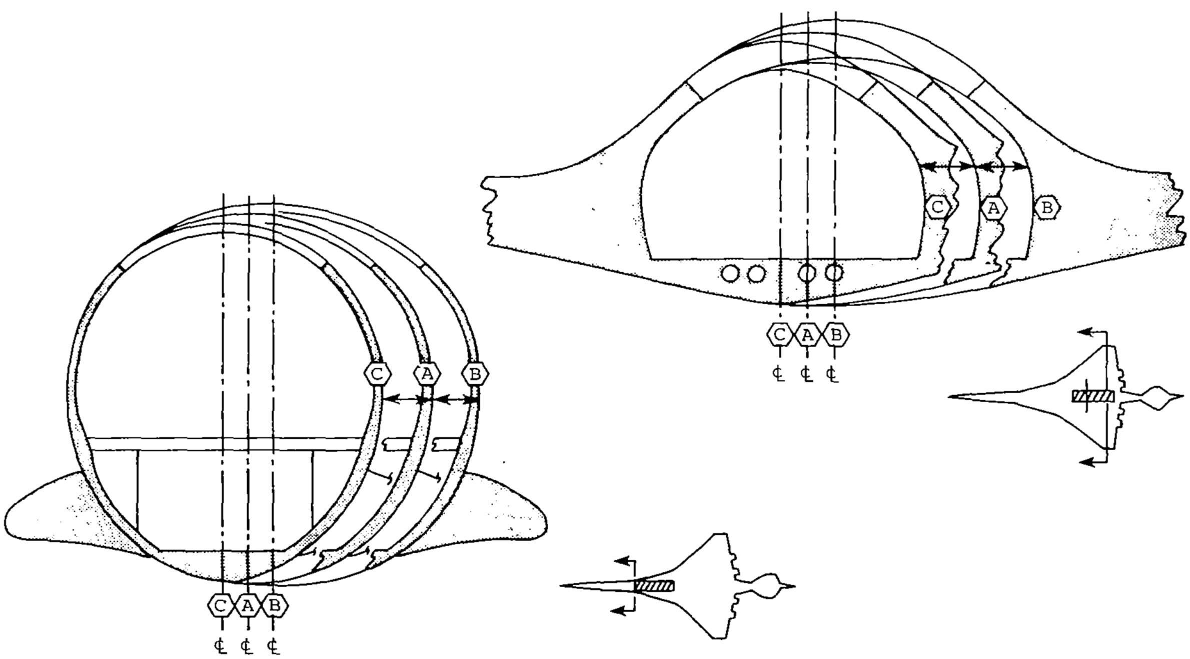


253 passengers



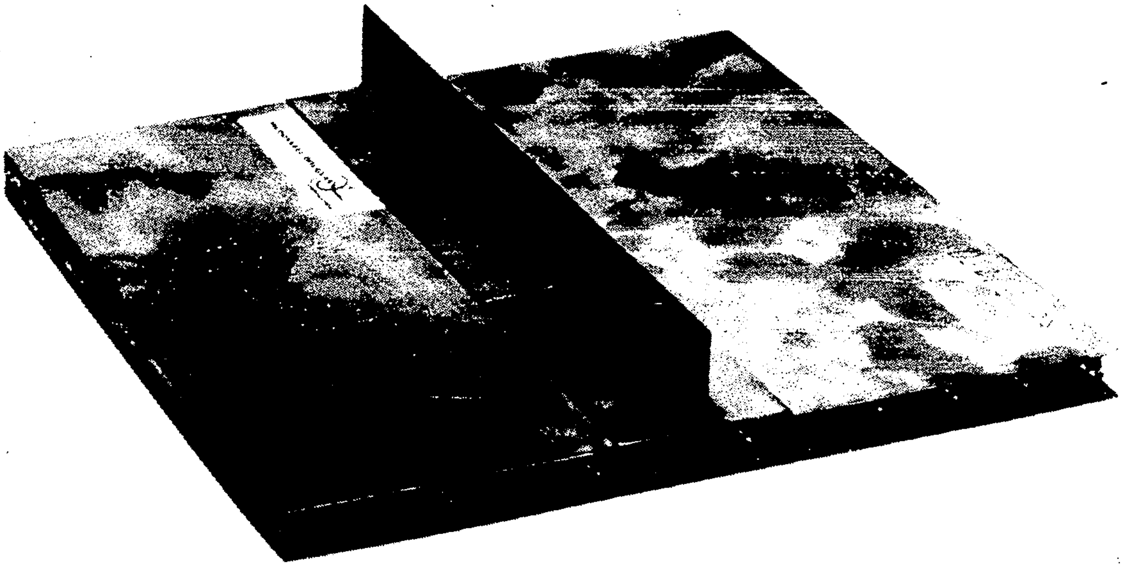
308 passengers

(g) Layout for seating arrangements.

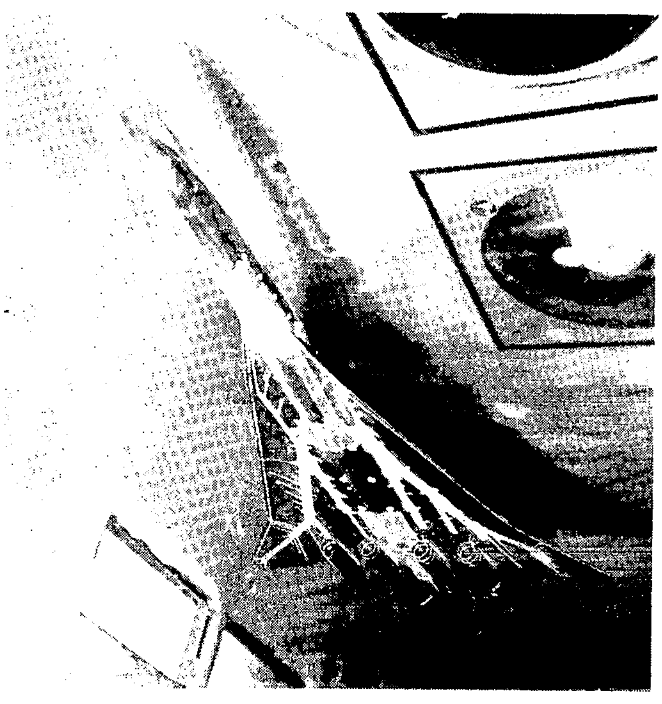


(h) Wide-body fuselage stretch concept.

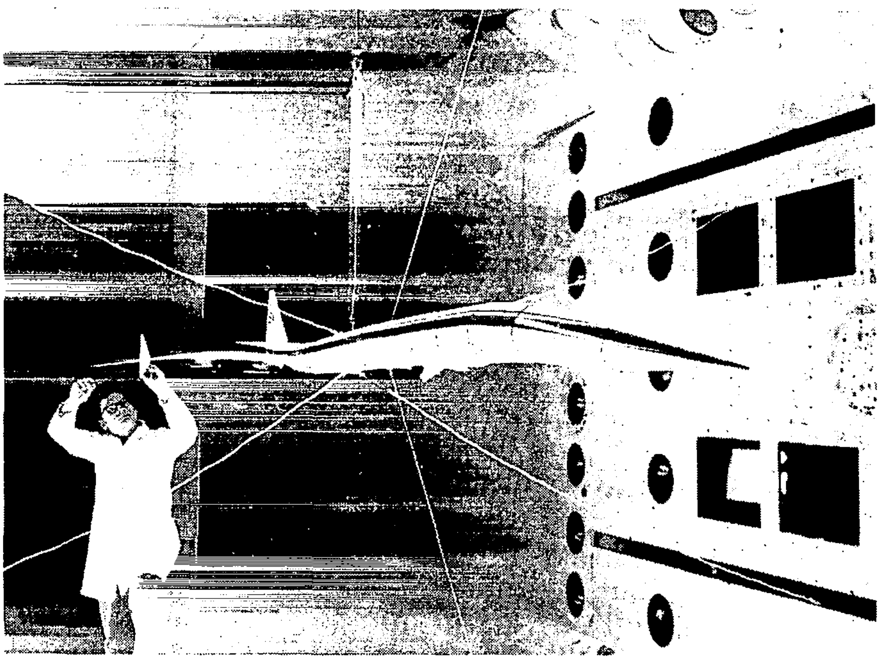
Figure 3.- Continued.



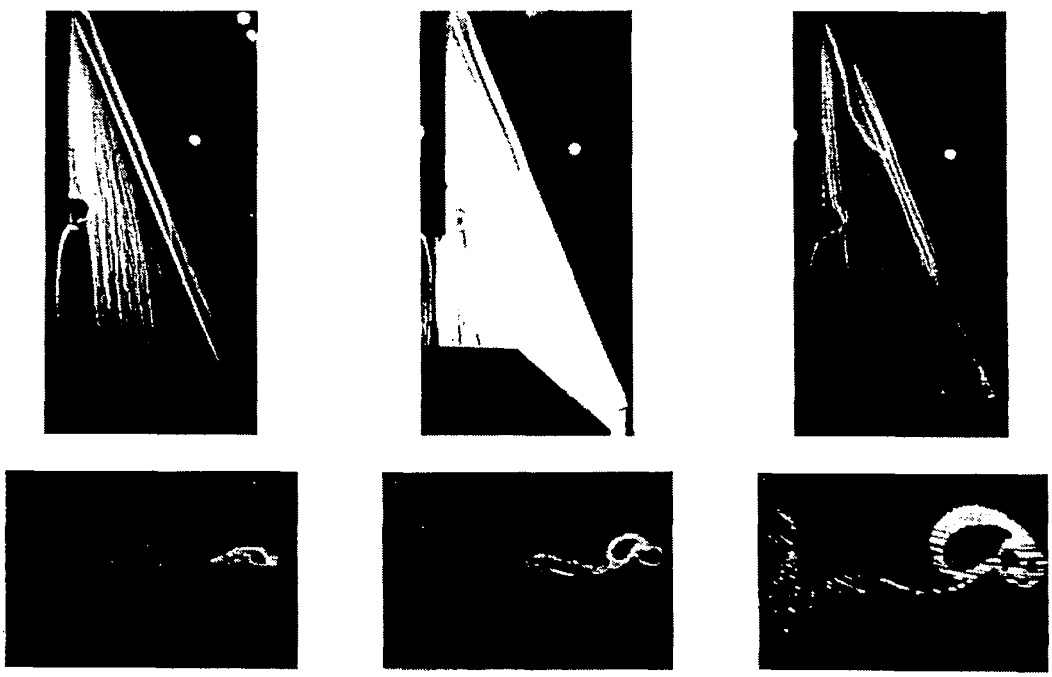
(i) Experimental SPF/DB sandwich panel.



(j) Model in high-speed wind tunnel.
Figure 3.- Continued.



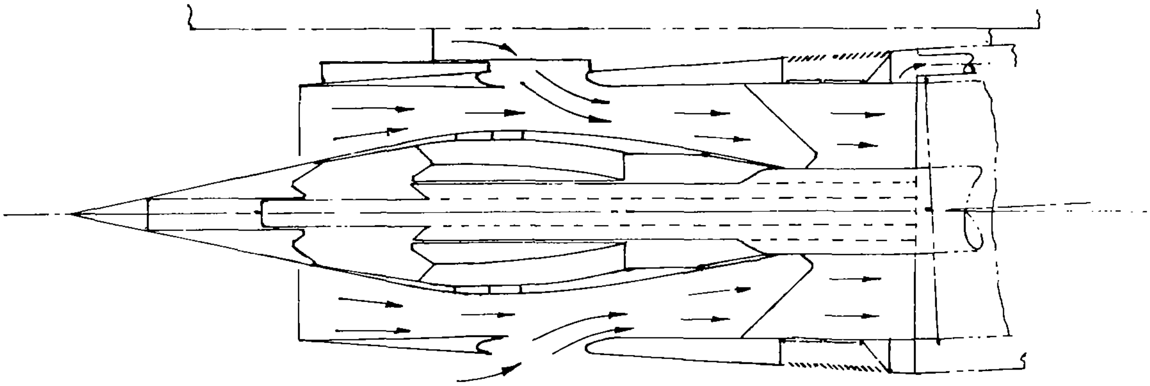
(k) Cable-mounted flutter model in wind tunnel.



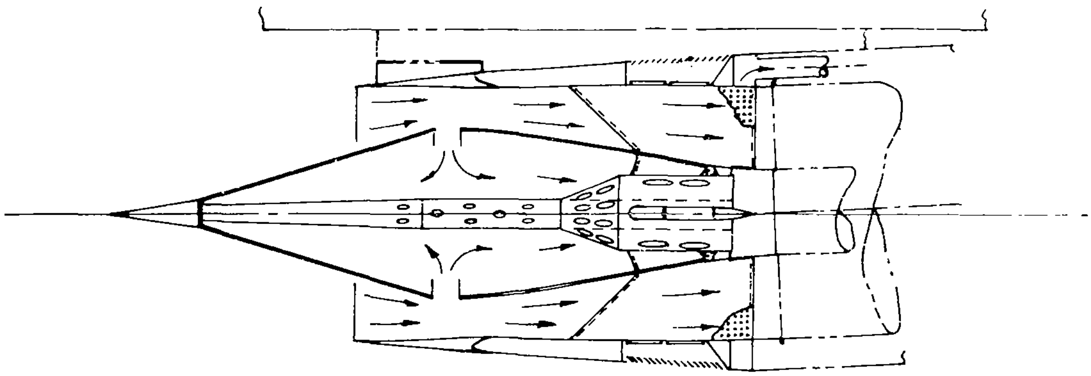
α = 5 degrees α = 10 degrees α = 15 degrees

(l) Oil flow and wake survey at various angles of attack.

Figure 3.- Continued.

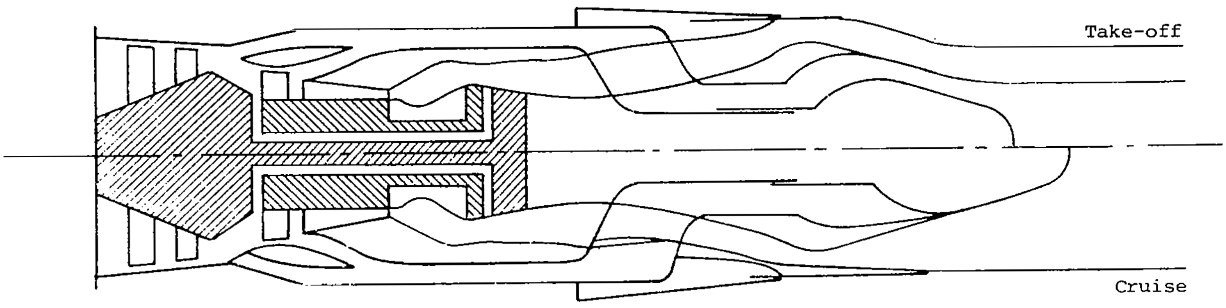


(m) Concept of translating centerbody inlet.

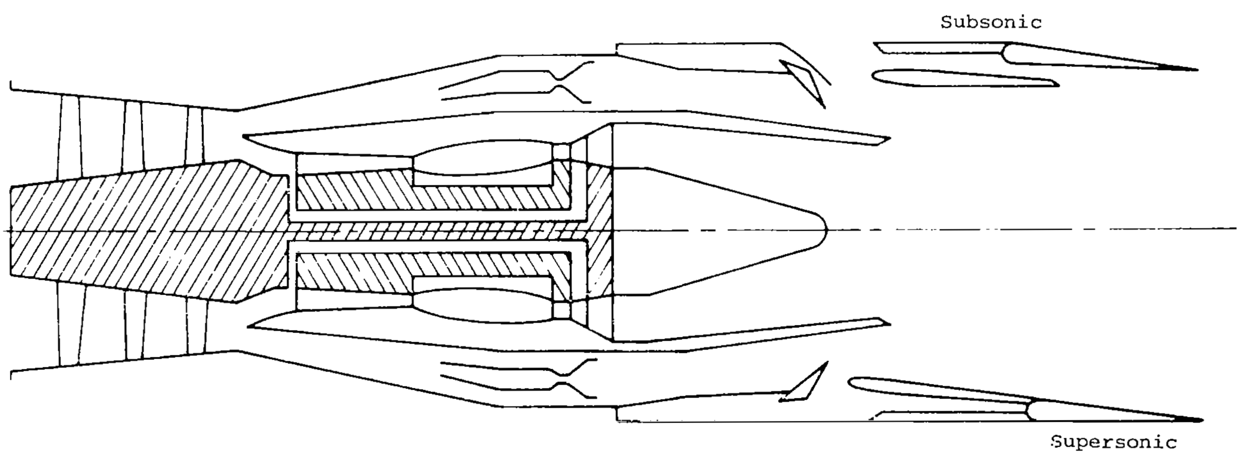


(n) Concept of bicone inlet.

Figure 3.- Continued.

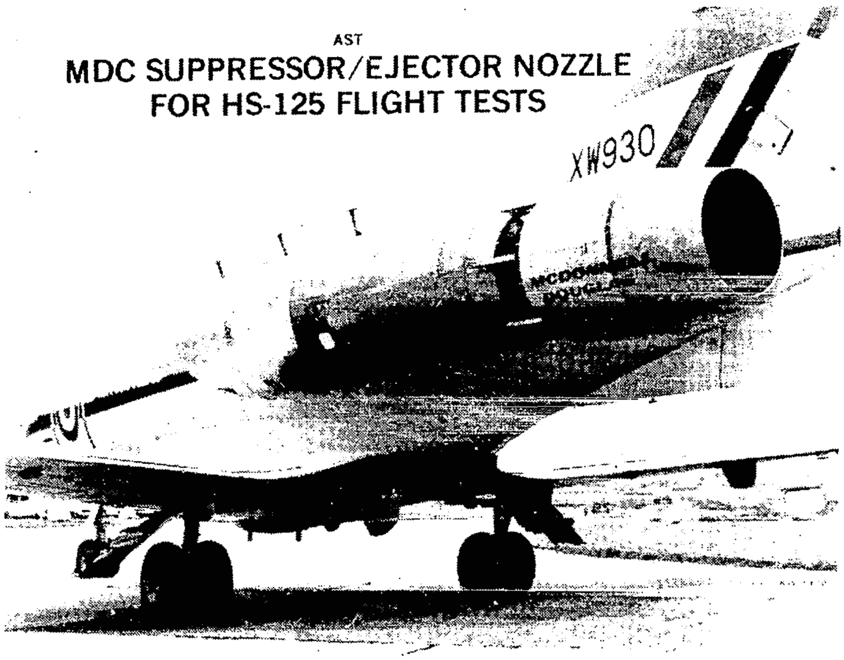


(o) Concept of double bypass engine.

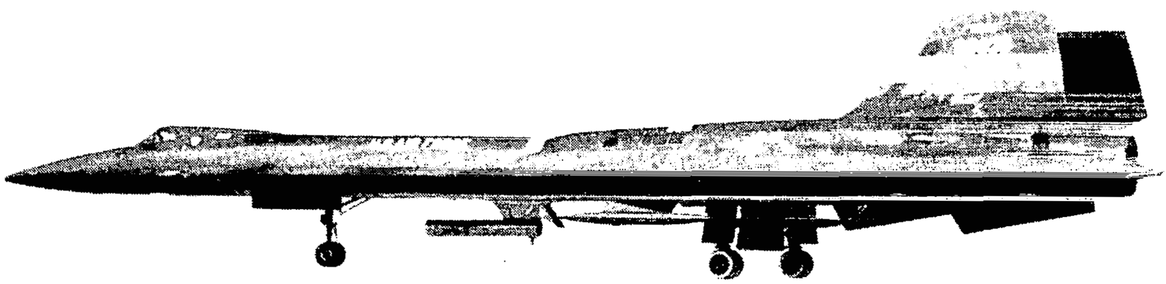


(p) Concept of variable-cycle duct-heating turbofan engine.

Figure 3.- Continued.

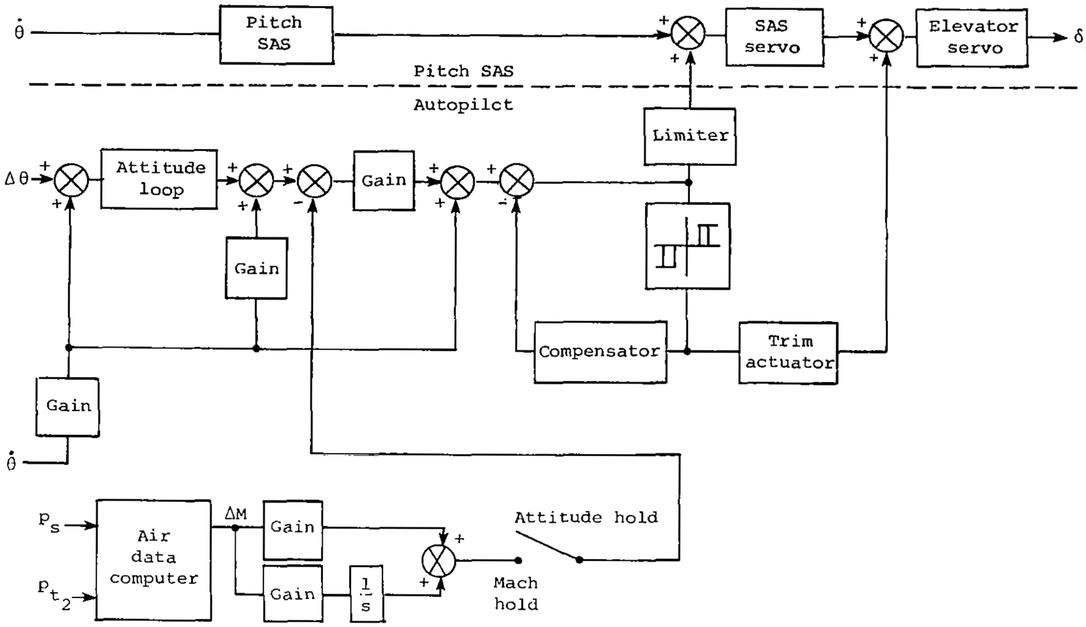


(q) Suppressor/ejector nozzle for flight tests.

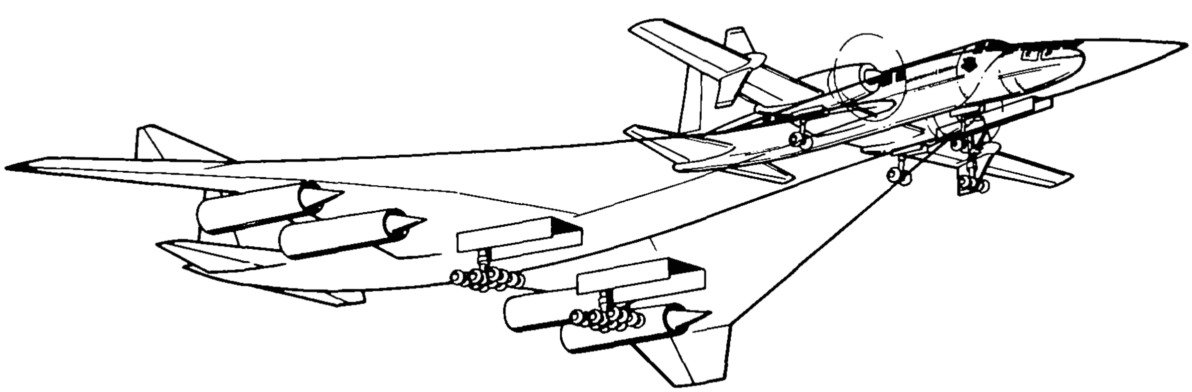


(r) Research airplane with SCR test cylinder.

Figure 3.- Continued.



(s) A Mach hold control system.



(t) Total in-flight simulation of model concept.

Figure 3.- Concluded.

BIBLIOGRAPHIC ENTRIES

This bibliography covers the time period from 1977 to mid-1980. A previous bibliography, NASA RP-1003, covers the first 5 years of the program, 1972 to mid-1977. For completeness, the present report also includes a few publications that were omitted in the first bibliography and several non-SCR papers which support the program. Unfortunately, some relevant papers are not generally available and therefore could not be included. When material was published in more than one form, the most recent and/or the most accessible document is cited.

The bibliography is alphabetically arranged according to system studies and the five SCR disciplines as follows:

Propulsion
Stratospheric Emission Impact
Structures and Materials
Aerodynamic Performance
Stability and Controls

Since airframe/propulsion-system interaction was initiated in fiscal year 1979, there are no publications to date. A multidisciplinary document is listed under the primary discipline addressed. For instance, documents on unsteady aerodynamics are listed under structures and materials when they address structural criteria, loads, and design; and, under aerodynamic performance when they address theoretical methodology and aerodynamics. Each discipline is subdivided into three groups:

NASA Formal Reports
NASA Contractor Reports
Articles, Meeting Papers, and Company Reports

Abstracts are provided for all NASA formal reports and NASA contractor reports. License was taken to modify or shorten abstracts. Included with the citations are NASA accession numbers (when useful and available), contractors, and contract numbers. Indexes of authors and NASA report numbers are presented at the end of the bibliography. There are 306 NASA reports and 135 articles, meeting papers, and company reports cited in this document.

SCR SYSTEM STUDIES

NASA Formal Reports

1 **Proceedings of the SCAR Conference.** NASA CP-001, [1977]. (Part 1: N77-17996, Part 2: N77-18019)

Part 1.- The Supersonic Cruise Aircraft Research (SCAR) team analyzed six major topics: (1) aerodynamics, (2) stability and control, (3) propulsion, (4) environmental factors, (5) airframe structures and materials, and (6) design integration.

Part 2.- Development advancements of the Supersonic Cruise Aircraft are discussed including environmental engineering, aircraft structures and materials, and design integration.

2 **Supersonic Cruise Research '79.** NASA CP-2108, 1980. (Part 1: X80-72343, Part 2: X80-72367)

Since 1972 the Supersonic Cruise Research (SCR) Program has provided an accelerated and focused technology effort which has resulted in development of improved analytical techniques, design procedures, and an expanded experimental data base. Significant achievements since the previous SCAR conference in 1976 (see NASA CP-001, Parts 1 and 2, entry 1) were reported to the technical community at the SCR '79 Conference held at Langley Research Center, November 13-16, 1979. This document is a compilation of papers, authored by representatives of airframe and engine manufacturers, the Federal Aviation Administration, three NASA research centers, and the Office of Technology Assessment (Congress of the United States), which were presented at the latter Conference.

3 **YF-12 Experiments Symposium.** NASA CP-2054, 1978. (Volume 1: N78-32055, *Volume 2: X79-10157, *Volume 3: X79-72834)

Papers presented by personnel from the Dryden Flight Research Center, the Lewis Research Center, and the Ames Research Center are presented. Topics cover propulsion system performance, inlet time varying distortion, structures, aircraft controls, propulsion controls, and aerodynamics. The reports were based on analytical studies, laboratory experiments, wind tunnel tests, and extensive flight research with two YF-12 airplanes.

*Classified.

4 Baber, Hal T., Jr.: **Characteristics of the Advanced Supersonic Technology AST-105-1 Configured for Transpacific Range With Pratt and Whitney Aircraft Variable Stream Control Engines.** NASA TM-78818, 1979. (N79-23888)

Credence to systems weights and assurance that the noise study AST concept can be balanced were studied. Current titanium structural technology is assumed. A duct-burning turbofan variable stream control engine (VSCE), with noise reduction potential through use of a coannular nozzle, was used. With 273 passengers, the range of the AST-105-1 for a cruise Mach number of 2.62 is essentially transpacific. Lift-to-drag ratio is slightly higher than for previous AST configurations. It is trimmable over a center-of-gravity range of 2.7 m (15.5 ft).

5 Bower, Robert E.: **The Promise of Advanced Technology for Future Air Transports.** NASA TM-78712, 1978. (N78-22075)

Progress in all weather 4-D navigation and wake vortex attenuation research is discussed and the concept of time based metering of aircraft is recommended for increased emphasis. The far term advances in aircraft efficiency were shown to be skin friction reduction and advanced configuration types. The promise of very large aircraft, possibly all wing aircraft, is discussed, as is an advanced concept for an aerial relay transportation system. Very significant technological developments were identified that can improve supersonic transport performance and reduce noise. The hypersonic transport was proposed as the ultimate step in air transportation in the atmosphere. Progress in the key technology areas of propulsion and structures was reviewed. Finally, the impact of alternate fuels on future air transports was considered and shown not to be a growth constraint.

6 Clauss, J. S., Jr.; Bruckman, F. A.; Horning, D. L.; Johnston, R. H.; and Werner, J. V.: **The Impact of Materials Technology and Operational Constraints on the Economics of Cruise Speed Selection.** Supersonic Cruise Research '79—Part 2, NASA CP-2108, 1980, pp. 909-934. (In X80-72367)

A study was conducted to evaluate the impact of materials technology on the economic viability of supersonic transports, and to determine the effect of cruise Mach number on these evaluations. Six material concepts at Mach 2.0 and three material concepts at Mach 2.55 were proposed. The economic figure of merit was supersonic fare premium over subsonic economy for an acceptable airline return on investment. The fare premium goal was 10 percent. The resulting evaluations, based on projected development, production, and operating costs, indicate that aircraft designs with advanced composites as the primary material ingredient have the lowest fare premiums at both Mach 2.0 and 2.55. The values are 11 percent and 16 percent, respectively. The designs having advanced metallics as the primary material ingredient are not as economical. Advanced titanium, employing advanced manufacturing methods such as SPF/DB, requires a fare premium of about 30 percent at both Mach 2.0 and 2.55. Advanced aluminum, usable only at the lower Mach number, requires a fare premium of 20 percent. Cruise speeds in the Mach 2.0 to 2.3 regime are preferred because of the better economics and because of the availability of two material concepts to reduce program risk – advanced composites and advanced aluminums. This cruise speed regime also avoids the increase in risk associated with the more complex inlets and airframe systems and higher temperature composite matrices required at the higher Mach numbers typified by Mach 2.55.

7 Driver, Cornelius: **Progress in Supersonic Cruise Aircraft Technology.** CTOL Transport Technology – 1978, NASA CP-2036, Pt. II, 1978, pp. 909-925. (In N78-29046)

Available as NASA TM-78695, 1978. (N78-23047)

The Supersonic Cruise Aircraft Research (SCAR) Program identified significant improvements in the technology areas of propulsion, aerodynamics, structures, take-off and landing procedures, and adanced configuration concepts. A brief overview of the highlights of the NASA supersonic technology program is presented.

8 Driver, Cornelius: **The Role of Technology as Air Transportation Faces the Fuel Situation.** NASA TM-81793, 1980. (N80-20260)

Perspectives on the air transportation fuel situation are discussed including intercity air traffic, airline fuel consumption, fuel price effects on ticket price, and projected traffic and fuel usage between now and the year 2000. Actions taken by the airlines to reduce consumption are reviewed, as well as efforts currently underway to improve fuel consumption. Longer range technology payoffs resulting from NASA research programs are reviewed and results from studies on the use of alternate fuels are discussed.

9 Duerr, Robert A.; and Diehl, Larry A.: **Advanced Technology for Controlling Pollutant Emissions From Supersonic Cruise Aircraft.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 535-549. (In X80-72343)

This paper presents and discusses some of the results obtained from research and development programs being sponsored or conducted by NASA. The objectives of these programs were to evolve and evaluate new gas-turbine-engine combustor technology for the reduction of pollutant emissions. Activities ranging from investigating variations of conventional combustion systems to evaluating advanced combustor concepts have been and continue to be pursued. Projected results and far-term technology efforts aimed at applying the premixed-prevaporized and catalytic combustion techniques to aircraft combustion systems indicate a potential for significant reductions in pollutant emission levels.

10 FitzSimmons, Richard D.: **Effects of an AST Program on U.S. Titanium Story.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 713-736. (In X80-72367)

The singular importance of titanium as the primary structural material for an efficient advanced supersonic transport (AST) is outlined. The advantages of titanium over other metals are shown to apply to future subsonic aircraft as well as for supersonic designs. The cost problem of titanium is addressed and shown to be markedly reduced by the emerging technologies of superplastic-forming/diffusion-bonding sandwich, hot isostatic pressing of titanium powders; and isothermal forgings IF demonstration programs should validate preliminary findings. The impact of a U.S. AST program on the United States titanium supply and demand picture is postulated.

11 Foss, Willard E., Jr.: **A Computer Program for Detailed Analysis of the Takeoff and Approach Performance Capabilities of Transport Category Aircraft.** NASA TM-80120, 1979. (N79-29141)

The takeoff and approach performance of an aircraft is calculated in accordance with the airworthiness standards of the Federal Aviation Regulations. The aircraft and flight constraints are represented in sufficient detail to permit realistic sensitivity studies in terms of either configuration modifications or changes in operational procedures. The program may be used to investigate advanced operational procedures for noise alleviation such as programmed throttle and flap controls. Extensive profile time history data are generated and are placed on an interface file which can be input directly to the NASA aircraft noise prediction program (ANOPP).

12 Foss, Willard E., Jr.; and Sorrells, Russell B., III: **Trade Studies Relating to a Long Range Mach 2.6 Supercruiser.** NASA TM-78811, 1978. (N79-15906)

A systems study was conducted on an aircraft concept respresentative of a supersonic-cruise military aircraft (supercruiser). The study results indicate that supersonic ranges in excess of 4000 n.mi. at a Mach number of 2.62 are possible. Trade studies, to determine the sensitivity of supersonic range to parameters which would improve maneuverability, indicate that thrust-weight ratios of as much as 0.5 can be used without significantly decreasing supersonic range; however, increasing the thrust-weight ratio to 1.0 decreases the range capability by about 1100 n.mi. The range penalty for increasing the aircraft limit load factor from 4.0 to 9.0 is about 500 n.mi.

13 Hadaller, O. J.; Schmidt, J. E.; Momenthy, A. M.; and Johnson, P. E.: **Impact of Changing Fuel Characteristics on Supersonic Cruise Airplane.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 855-852. (In X80-72367)

The question of an advanced supersonic cruise research (SCR) airplane is related to future oil supplies and prices. The object of the study reported in this paper was to develop technical data on the impact of changing fuel characteristics on the SCR airplane. Projections of crude oil characteristics typical of the 1985-to-2000 time period were made with the help of consultants to the oil industry. Refineries for the future were modeled to establish jet fuel yield and property data. Candidate jet fuels were than related to requirements of engine and aircraft systems for future airplanes, with emphasis on supersonic cruise airplanes. The study results do not show a need for broadening the fuel specification. Hypothetical study fuels with broader specifications were defined, however, as was the impact of their properties on the SCR airplane and systems.

14 Hoffman, Sherwood: **Bibliography of Supersonic Cruise Aircraft Research (SCAR) Program From 1972 to Mid-1977.** NASA RP-1003, 1977. (N78-12895)

This bibliography documents publications of the supersonic cruise aircraft research (SCAR) program that were generated during the first 5 years of effort. The reports are arranged according to systems studies and five SCAR disciplines: propulsion, stratospheric emissions impact, structures and materials, aerodynamic performance, and stability and control. The specific objectives of each discipline are summarized. Annotation is included for all NASA in-house and low-number contractor reports. There are 444 papers and articles included.

15 Kelly, Robert: **Supersonic Cruise Vehicle Research/Business Jet.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 935-949. (In X80-72367)

A comparison study of a GE-21 variable-cycle propulsion system with a multimode integrated propulsion system (MMIPS) was conducted while installed in small $M = 2.7$ supersonic cruise vehicles with military and business jet possibilities. The 1984 state-of-the-art vehicles were sized to the same transatlantic range, takeoff distance, and sideline noise. The results indicate the MMIPS would result in a heavier vehicle with better subsonic cruise performance. The MMIPS arrangement with one fan engine and two satellite turbojet engines would not be appropriate for a small supersonic business jet because of design integration penalties and lack of redundancy.

16 Landes, Karyl H.; and Matter, J. A.: **Long-Range Airplane Study – The Consumer Looks at SST Travel.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 759-804. (In X80-72367)

The Boeing Company and its subsidiary, Boeing Computer Services, retained Gilmore Research Group to conduct a study among long-range air travelers to ascertain attitudes toward several basic air travel decisions. Of interest were tradeoffs involving time versus comfort and time versus cost as they pertain to supersonic versus conventional wide-body aircraft on overseas routes. The market focused upon was the segment of air travelers most likely to make that type of tradeoff decision: those having flown overseas routes for business or personal reasons in the recent past. The information generated by the study is intended to provide quantifiable insight into consumer demand for supersonic as compared to wide-body aircraft alternatives for long-range overseas air travel.

17 Leyman, Clive S.: **Concorde With the Airlines.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 741-757. (In X80-72367)

Concorde entered service with Air France and British Airways on January 21, 1976. Since then the aircraft has carried 400 000 passengers over 40 million kilometers (25 million miles) and accumulated 30 000 flying hours – enough to take a sober look at the realities of supersonic aircraft operations. Airline managers buy aircraft, and if designers and manufacturers wish to assess the potential for future supersonic operations, they must try to see Concorde through the eyes of the airlines.

18 Maddalon, Dal V.: **Estimating Airline Operating Costs.** CTOL Transport Technology – 1978, NASA CP-2036, Pt. II, 1978, pp. 849-870. (In N78-29046)

Available as NASA TM-78694, 1978. (N78-23046)

A review was made of the factors affecting commercial aircraft operating and delay costs. For this work, an airline operating cost model was developed which includes a method for estimating the labor and material costs of individual airframe maintenance systems. The model, similar in some respects to the standard Air Transport Association of America (ATA) Direct Operating Cost Model, permits estimates of aircraft-related costs not now included in the standard ATA model (e.g., aircraft service, landing fees, flight attendants, and control fees). A study of the cost of aircraft delay was also made and a method for estimating the cost of certain types of airline delay is described.

19 Maglieri, Domenic J.; Carlson, Harry W.; and Hubbard, Harvey H.: **Status of Knowledge of Sonic Booms.** NASA TM-80113, 1979. (N79-24955)

The status of sonic boom technology with emphasis on the recent research results is summarized. Included are definitions of the boom carpets, both primary and secondary, a discussion of existing experience with primary booms including the status of overpressure predictions and boom minimization methodology through airplane design, an indication of the boom waveforms and audibility, and a discussion of focus booms resulting from aircraft maneuvers as well as the effect of abnormal atmospheric conditions on these maneuver booms.

20 Mascitti, Vincent R.: **A Preliminary Study of the Performance and Characteristics of a Supersonic Executive Aircraft.** NASA TM-74055, 1977. (N78-13040)

The impact of advanced supersonic technologies on the performance and characteristics of a supersonic executive aircraft was studied in four configurations with different engine locations and wing/body blending and an advanced nonafterburning turbojet or variable cycle engine. A Mach 2.2 design Douglas scaled arrow-wing was used with Learjet 35 accommodations. All four configurations with turbojet engines meet the performance goals of 5926 km (3200 n.mi.) range, 1981 m (6500 ft) takeoff field length, and 77 m/sec (150 knots) approach speed. The noise levels of turbojet configurations studied are excessive. However, a turbojet with mechanical suppressor was not studied.

21 Maxwell, R. L.; and Dickinson, L. V., Jr.: **Assessment of the Impact of Advanced Air-Transport Technology.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 805-819. (In X80-72367)

In 1978, the Chairman of the House Science and Technology Committee requested that the Office of Technology Assessment perform a technology assessment "to provide a fresh look at the impact of eventual widescale introduction of advanced high speed aircraft." The specific issue raised was whether the potential benefits of advanced supersonic transport aircraft warrant the Federal Government increasing the level of its support during the next steps, which would be to validate concepts and develop the technology. The assessment examines the potential future for large long range aircraft, which include advanced subsonic, advanced supersonic, and even hypersonic vehicles. This paper is confined primarily to the findings of this study of advanced long range aircraft.

22 Nagel, A. L.: **Studies of Advanced Transport Aircraft.** CTOL Transport Technology – 1978, NASA CP-2036, Part II, 1978, pp. 951-982. (In N78-29046)

Available as NASA TM-78697, 1978. (N78-25047)

Concepts for possible future airplanes are studied that include all-wing distributed-load airplanes, multi-body airplanes, a long-range laminar flow control airplane, a nuclear-powered airplane designed for towing conventionally powered airplanes during long-range cruise, and an aerial transportation system comprised of continuously flying liner airplanes operated in conjunction with short-range feeder airplanes. Results indicate that each of these concepts has the potential for important performance and economic advantages, provided that certain suggested research tasks are successfully accomplished. Indicated research areas include all-wing airplane aerodynamics, aerial rendezvous, nuclear aircraft engines, air-cushion landing systems, and laminar flow control, as well as the basic research discipline areas of aerodynamics, structures, propulsion, avionics, and computer applications.

23 Neumann, Frank D.; and Whitten, Jerry W.: **A Family of Supersonic Airplanes – Technical and Economic Feasibility.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 833-854. (In X80-72367)

The success of the subsonic jet transport airplane has been due, in part, to the manufacturer's ability to expand basic models into airplane families to satisfy emerging market requirements, giving the airlines the right airplane for the right market. The technical feasibility of this cost-effective family approach to the design of supersonic airplanes has now been established. Exciting possibilities can be projected on the performance and economic characteristics of a family of supersonic airplanes. Despite the severe constraints imposed by uncertain fuel costs and environmental considerations, it appears that overwater global, truly-rapid transit is within reach of being economically attractive to the majority of air travellers without becoming a financial or environmental burden to the general public.

24 Pao, S. Paul; Wenzel, Alan R.; and Oncley, Paul B.: **Prediction of Ground Effects on Aircraft Noise.** NASA TP-1104, 1978. (N78-17823)

A unified method is recommended for predicting ground effects on noise. This method may be used in flyover noise predictions and in correcting static test-stand data to free-field conditions. The recommendation is based on a review of recent progress in the theory of ground effects and of the experimental evidence which supports this theory. It is shown that a surface wave must be included sometimes in the prediction method. Prediction equations are collected conveniently in a single section of the paper. Methods of measuring ground impedance and the resulting ground-impedance data are also reviewed because the recommended method is based on a locally reactive impedance boundary model. Current practice of estimating ground effects is reviewed and consideration is given to practical problems in applying the recommended method. These problems include finite frequency band filters, finite source dimension, wind and temperature gradients, and signal incoherence.

25 Powell, Clemans A.; and McCurdy, David A.: **Comparison of Low-Frequency Noise Levels of the Concorde Supersonic Transport With Other Commercial Service Airplanes.** NASA TM-78736, 1978. (N78-33873)

Fifty-two airplane noise recordings, made at several locations around Dulles International Airport, were analyzed to compare the low-frequency noise levels of the Concorde supersonic transport with those of other commercial jet airplanes. Comparisons of the relative low-frequency noise levels which were produced at close and distant locations for departures and arrivals were made for three noise measures: the sound pressure level and the one-third octave band centered at 20 Hz, the total sound pressure level in the one-third octave bands with center frequencies less than or equal to 125 Hz, and the total sound pressure level in the one-third octave bands with center frequencies less than or equal to 500 Hz. Although the absolute noise levels for Concorde were found, in general, to be higher than those for the other airplane types, the level of low-frequency noise of the Concorde relative to the perceived noise level (PNL), effective perceived noise level (EPNL), and overall sound pressure level (OASPL) was within the range established by the other airplane types, except for the arrival operations of four-engine, narrow-body airplanes. The measure OASPL was found to be a significantly better predictor of low-frequency noise level than PNL or EPNL.

26 Raney, John P.: **Noise Prediction Technology for CTOL Aircraft.** CTOL Transport Technology – 1978, NASA CP-2036, Pt. II, 1978, pp. 805-818. (In N78-29046)

Available as NASA TM-78700, 1978. (N78-23875)

The application of a new aircraft noise prediction program to CTOL noise prediction is outlined. Noise prediction is based on semiempirical methods for each of the propulsive system noise sources, such as the fan, the combustor, the turbine, and jet mixing, with noise critical parameter values derived from the thermodynamic cycle of the engine. Comparisons of measured and predicted noise levels for existing CTOL aircraft indicate an acceptable level of accuracy.

27 Rochte, Lucian S.: **Supersonic Market and Economic Analyses.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 889-907. (In X80-72367)

Projections are made of advanced supersonic transport (AST) markets of the free world for the period 1985-2004. Estimates are made of passenger traffic volume, airplane range, and seat-capacity requirements for Mach 2.2 service by international regional market areas and by city-pairs within and between these areas. The volume of candidate traffic consists of first class and full-fare economy class passengers of the international, long-haul, overwater routes and such tag-end markets as are needed to fill out airline network patterns. Market and traffic factors examined include variable load factors, growth rates, supersonic transport market shares, and schedule frequencies considering the different makeup of passenger traffic for the individual city-pairs. Economic factors analyzed include direct, indirect, and total operating costs and yield levels for first class and full-fare economy class traffic.

28 Rowe, William T.: **Technology Development Status at McDonnell Douglas.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 873-888. (In X80-72367)

During the 1979 SCR Conference, a presentation was included to provide the highlights of technology development activities at McDonnell Douglas. The presentation charts are included, along with a brief written explanation for each. Charts discussed include SST technology comparison, aerodynamic efficiency, low-speed-model 10-percent-scale tests, control systems, structural models, weight and cost comparisons, SPF/DB titanium accomplishments, suppressor/ejector nozzle test, nozzle performance, noise summary, airframe/engine integration, bicone inlet, fuel efficiency comparison, total operating costs, market summary, environmental issues, high priority technology items, technology validation, and summary.

29 Sigalla, A.: **Overview of Boeing Supersonic Transport Efforts – 1971-1979.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 821-832. (In X80-72367)

The state of the art in supersonic cruise technology has been advanced continuously at the Boeing Company since the United States supersonic transport program was cancelled. Following that cancellation, the status of the technology was assessed carefully and emphasis was put on finding solutions for what had been considered the major technical difficulties. In particular, work on the breakthroughs needed to advance the technology was emphasized. This was done to ensure that eventual practical application of the technology would establish the design feasibility of economically successful and environmentally satisfactory highly-productive, supersonic, cruise airplanes. Solutions to all major technical problems have been identified. Depending on the subject, either the problem is no longer a concern or the steps needed to bring about a solution have been mapped out clearly. This paper outlines the accomplishments of the Boeing Company's supersonic transport studies and complements other papers presented at this conference.

30 Staff, Langley Research Center: **Noise and Performance Calibration Study of a Mach 2.2 Supersonic Cruise Aircraft.** NASA TM-80043, 1979. (N79-21869)

The baseline configuration of a Mach 2.2 supersonic cruise concept, employing a 1980-1985 technology level, dry turbojet, mechanically suppressed engine, was calibrated to identify differences in noise levels and performance as determined by the methodology and ground rules used. In addition, economic and noise information is provided consistent with a previous study based on an advanced technology Mach 2.7 configuration, reported separately. Results indicate that the difference between NASA and manufacturer performance methodology is small. Resizing the aircraft to NASA ground rules results in negligible changes in takeoff noise levels (less than 1 EPNdB) but approach noise is reduced by 5.3 EPNdB as a result.

31 Staff, Langley Research Center: **Preliminary Noise Tradeoff Study of a Mach 2.7 Cruise Aircraft.** NASA TM-78732, 1979. (N79-21868)

NASA computer codes in the areas of preliminary sizing and en route performance, takeoff and landing performance, aircraft noise prediction, and economics were used in a preliminary noise tradeoff study for a Mach 2.7 supersonic cruise concept. Aerodynamic configuration data were based on wind-tunnel model tests and related analyses. Aircraft structural characteristics and weight were based on advanced structural design methodologies, assuming conventional titanium technology. The most advanced noise prediction techniques available were used, and aircraft operating costs were estimated using accepted industry methods.

32 Stone, James R.; and Gutierrez, Orlando A.: **Status of Noise Technology for Advanced Supersonic Cruise Aircraft.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 493-518. (In X80-72343)

During the past several years, progress has been made in several areas of acoustic technology applicable to advanced supersonic cruise aircraft. This paper reviews some of the more important developments, which relate primarily to jet noise and its suppression. The noise-reducing potential of high-radius-ratio, inverted-velocity-profile coannular jets is demonstrated by model-scale results from a wide range of nozzle geometries, including some simulated flight cases. These results have been verified statically at large scale on a variable-cycle-engine (VCE) testbed. A preliminary assessment of potential VCE noise sources such as fan and core noise is made, based on the testbed data. Recent advances in the understanding of flight effects are reviewed. The status of component noise prediction methods is assessed on the basis of recent test data, and the remaining problem areas are outlined.

33 Sundararaman, N.: **Environmental Effects of Aircraft at Cruise: An Update.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 519-534. (In X80-72343)

New laboratory determinations of chemical reaction rates and modeling refinements have shown that the effect of cruise-altitude emissions on stratospheric ozone has changed from one of ozone decrease to one of flight increase. The situation, however, is not yet fully resolved, since the uncertainties in the model predictions have not been adequately quantified. The status of the calculations of ozone change due to high altitude aircraft is critically reviewed and important areas of uncertainty identified.

NASA Contractor Reports

34 *Boeing Commercial Airplane Co.: **Advanced Concept Studies for Supersonic Vehicles.** NASA CR-145286, 1978. (X78-10030)

Technical studies aimed at defining the characteristics and research requirements for supersonic cruise aircraft that offer superior performance, reduced fuel consumption, less noise and environmental impact, as well as economical acquisition and operating cost are summarized. Specific technological advances were identified, developed, and verified to some extent. Some of these advances are reported, and it is shown that their judicious integration into practical airplane design concepts is feasible.

*Boeing Commercial Airplane Co., contract NAS1-14623.

35 *Boeing Commercial Airplane Co.: **Advanced Concept Studies for Supersonic Vehicles.** NASA CR-159028, 1979. (X79-10103)

The technological advancements of airplane systems were assessed. This includes the effects on systems resulting from airplane operational or structural improvements and potential gains from system modifications. This progress established confidence in the selected baseline configuration, a development of the U.S. SST design. The concept for a supersonic airplane family was validated and offers significant improvements in airplane operating economics.

*Boeing Commercial Airplane Co., contract NAS1-14623.

36 *Boeing Commercial Airplane Co.: **Advanced Concept Studies for Supersonic Vehicles.** NASA CR-159244, 1980.

In the past few years technical studies have been performed to define the characteristics and research requirements for future supersonic cruise aircraft that would offer superior performance, reduced fuel consumption, and less noise and environmental impact, as well as economical acquisition and operating cost. As a result, many technical advances important to the design of supersonic cruise aircraft have emerged. At the same time, environmental and performance goals that such airplanes will have to meet have become more clearly defined and are more stringent. In response to these new goals, specific technological advances have been identified, developed, and verified to some extent. Some of these advances are reported in this document and it is shown that their judicious integration into practical airplane design concepts is feasible. Thus the features, performance, and economic capabilities of possible future supersonic cruise aircraft are beginning to emerge. The studies were supported by General Electric and Pratt & Whitney Aircraft to provide data for respective variable-cycle engines, by The Pace Company of Houston to provide crude oil and refinery data projected for the late 1990's; and by Pratt & Whitney Aircraft to evaluate the impact of candidate fuels on engine design and operation. Areas of future required research are recommended to establish technology feasibility and to verify the potential of future efficient and economical supersonic cruise aircraft and variable-cycle engines.

*Boeing Commercial Airplane Co., contract NAS1-14623.

37 *Boeing Commercial Airplane Co.: **Economic Study of Multipurpose Advanced High-Speed Transport Configurations.** NASA CR-159126, 1979. (N80-13986)

This document describes the Economic Analysis Study which is part of a larger National Aeronautics and Space Administration Supersonic Cruise Research (NASA SCR) Program designed to identify and develop technology that may make it possible to define advanced supersonic airplanes. Ten airplanes were defined according to size, payload, and speed. The price, range capability, fuel burned, and block time were determined for each configuration; then operating costs and surcharges were calculated.

*Boeing Commercial Airplane Co., contract NAS1-14623.

38 *Boeing Commercial Airplane Co.: **Supersonic Cruise Aircraft Noise Sensitivity and Low-Speed Performance Improvement Studies.** NASA CR-145286-1, 1978.

Technical studies aimed at defining the characteristics and research requirements for supersonic cruise aircraft that offer superior performance, reduced fuel consumption, less noise and environmental impact, as well as economical acquisition and operating cost are summarized in NASA CR-145286 (entry 34) and this supplemental report. The results of additional low-speed noise sensitivity and performance studies are presented.

*Boeing Commercial Airplane Co., contract NAS1-14623.

39 *Boeing Commercial Airplane Co.: **Supersonic Cruise Research Airplane Study.** NASA CR-145212, 1977. (X78-10033)

The feasibility of using a subscale research airplane to replace the need for a larger second generation SST prototype is evaluated. The engine as well as the total airplane is considered. Questions of manufacturing technology, airplane post-prediction confidence, and the technical areas of aeroelastics, aerodynamics, flight controls, noise, systems, structures, weights, and propulsion including the variable-cycle engine are discussed.

*Boeing Commercial Airplane Co., contract NAS1-13559.

40 *Bond, E. Q.; Carroll, E. A.; and Flume, R. A.: **Study of the Impact of Cruise Speed on Scheduling and Productivity of Commercial Transport Aircraft – Report.** NASA CR-145189, 1977. (N77-24074)

A comparison is made between airplane productivity and utilization levels derived from commercial airline type schedules which were developed for two subsonic and four supersonic cruise speed aircraft. The cruise speed component is the only difference between the schedules which are based on 1995 passenger demand forecasts. Productivity-to-speed relationships were determined for the three discrete route systems: North Atlantic, Trans-Pacific, and North-South America. Related combinations of these route systems were also studied. Other areas affecting the productivity-to-speed relationship such as aircraft design range and scheduled turn time were examined.

*Lockheed-California Co., contract NAS1-14435.

41 *Brewer, G. D.; and Morris, R. E.: **Minimum Energy, Liquid Hydrogen Supersonic Cruise Vehicle Study.** NASA CR-137776, 1975. (N76-17101)

The potential was examined of hydrogen fueled supersonic vehicles designed for cruise at Mach 2.7 and at Mach 2.2. The aerodynamic weight and propulsion characteristics of a previously established design of a LH2 fueled, Mach 2.7 supersonic cruise vehicle (SCV) were critically reviewed and updated. The design of a Mach 2.2 SCV was established on a corresponding basis. These baseline designs were then studied to determine the potential of minimizing energy expenditure in performing their design mission, and to explore the effect of fuel price and noise restriction on their design and operating performance. The baseline designs of LH2 fueled aircraft were then compared with equivalent designs of jet A (conventional hydrocarbon) fueled SCV's. Use of liquid hydrogen for fuel for the subject aircraft provides significant advantages in performance, cost, noise, pollution, sonic boom, and energy utilization.

*Lockheed-California Co., contract NAS2-8781.

42 *Clauss, J. S., Jr.; Bruckman, F. A.; Bangert, L. H.; Carichner, G. E.; Guess, M. K., Jr.; Hays, A. P.; Jurey, L.; and Sakata, I. F.: **Supersonic Cruise Vehicle Technology Assessment Study of an Over/Under Engine Concept.** NASA CR-159247, 1980.

This report is a compilation of engineering analysis and test work completed by the Lockheed-California Company during FY 1979 on the NASA Supersonic Cruise Vehicle Technology Assessment Study of an Over/Under Engine Concept. The primary emphasis of the work was to update and advance the technology base applicable to the design and development of supersonic cruise vehicles (SCV), especially as related to future commercial transports. The FY 1979 technology assessment study was divided into five distinct technology study areas: planform refinement, airframe/propulsion integration, noise-reduction technology, advanced aluminum alloy development, and integrated active controls. The relative merits of changes to engine or airframe characteristics are evaluated according to their impact on a baseline aircraft configuration. Maximum takeoff weight of the baseline configuration is held constant so that improvements in the design increase its range.

*Lockheed-California Co., contract NAS1-14625.

43 *Clauss, J. S., Jr.; Hays, A. P.; and Wilson, J. R.: **The Common Case Study: Lockheed Design of a Supersonic Cruise Vehicle.** NASA CR-158935, 1978. (N78-33086)

The objective was to compare the characteristics of SST's designed for the same mission by Lockheed, McDonnell Douglas, British Aerospace (U.K.), Aerospatiale (France), and the USSR. This comparison was to be used to calibrate parametric design studies of the tradeoff between SST direct operating cost (DOC) and noise levels at the FAR 30 certification points. The guidelines for this common case study were to design an aircraft with the following mission: payload – 23 247 kg (51 250 lbm), range – 7000 km (3780 n.mi.), and cruise Mach number – 2.2. Field length was constrained to 3505 m (11 500 ft). Other airfield constraints and fuel reserves were also specified, but no noise constraints were applied.

*Lockheed-California Co., contract NAS1-14625.

44 *Douglas Aircraft Co.: **Advanced Technology Engine Integration/Acoustic Study.** NASA CR-159298, 1978.

This document presents the results of an advanced technology engine integration/acoustic study. It includes the results of the integration of two near term low bypass engines, two advanced technology low bypass engines, two advanced technology variable cycle engines, and an acoustics analysis of the engines installed in the baseline airplane.

*Douglas Aircraft Co., contract NAS1-14624.

45 *Douglas Aircraft Co.: **Aircraft Community Noise Impact Studies.** NASA CR-145152, 1977. (N77-24638)

The objectives of the study are to (1) conduct a program to determine the community noise impact of advanced technology engines when installed in supersonic aircraft, (2) determine the potential reduction in community noise by flight operational techniques for the study aircraft, (3) estimate the community noise impact of the study aircraft powered by suppressed turbojet engines and by advanced duct heating turbofan engines, and (4) compare the impact of the two supersonic designs with that of conventional commercial DC 8 aircraft.

*Douglas Aircraft Co., contract NAS1-14488.

46 *Douglas Aircraft Co.: **Evaluation of Bicone and Translating Centerbody Inlets for a M = 2.2 Supersonic Cruise Vehicle.** NASA CR-159157, 1979. (X79-10154)

This report presents the results of an analysis of inlets for supersonic cruise vehicles. The bicone inlet has the capability of a widely variable throat area so that engine airflow demands can be satisfied throughout the transonic flight regime. This study has developed the design of a bicone inlet for the Mach 2.2 MDC baseline aircraft to approximately the same depth of design detail as the translating centerbody inlet, which has been refined for the baseline.

*Douglas Aircraft Co., contract NAS1-14624.

47 *Douglas Aircraft Co.: **Reference Aircraft for ICAO Working Group E.** NASA CR-158929, 1978. (N78-32087)

The results of an advanced supersonic transport aircraft/engine integration study to be used as a detail preliminary design case to assist in the assessment of noise standards applicable to future supersonic transports are summarized. The design considered reflects the application of the advanced technologies which are projected to be available for program initiation in the 1980-1985 time period. Suppression characteristics included were obtained in simulated forward flight in the Rolls-Royce spin rig using a small scale model. The engine size selected produces a noise no greater than 108 EPNdB at any of the three FAR Part 36 (Stage 2) defined measuring points and is slightly larger than the optimum cruise size to meet this noise constraint condition.

*Douglas Aircraft Co., contract NAS1-14624.

48 *Douglas Aircraft Co.: **Technology Application Studies for Supersonic Cruise Aircraft.** NASA CR-145130, 1976. (X77-10017)

The technology assessment for a baseline design of a supersonic cruise aircraft is discussed. Inlet analysis, control system, engine, structural design, and wind tunnel models are described along with fuel management, landing gear water/slush analysis, and aerodynamic conclusions from high speed model data.

*Douglas Aircraft Co., contract NAS1-13612.

49 *Douglas Aircraft Co.: **Technology Application Study of a Supersonic Cruise Vehicle.** NASA CR-145287, 1977. (X78-10029)

Systems analysis and integration studies were conducted to define a new baseline configuration. The resulting configuration was based on analysis in the areas of aerodynamics, structures, mass properties, and configuration control. Other topics discussed include (1) active control system analysis; (2) aerodynamic reoptimization from model data; (3) determination of minimum gage titanium; (4) advanced structural analysis and tests; (5) flexible fuselage/landing-gear studies; (6) operational requirements; (7) climatic impact assessment; (8) aerodynamic design of low speed wind tunnel models; and (9) inlet design analysis.

*Douglas Aircraft Co., contract NAS1-14624.

50 *Douglas Aircraft Co.: **Technology Application Study of a Supersonic Cruise Vehicle With Improved Aerodynamic Efficiency (L/D).** NASA CR-159034, 1979. (X79-10160)

Aerodynamic, structural, propulsion, and configuration integration analysis of the Mach 2.2 baseline has identified an improved configuration with greatly increased range and lower structural cost. The L/D improvement is based on cooperative NASA/MDC high speed wind tunnel model results. Advanced technology (1982 go-ahead) engine cycles are refined in conjunction with Pratt & Whitney and General Electric which result in a better match for takeoff and for cruise. The MDC unique superplastic-forming/diffusion-bonding fabrication technique for the primary titanium structure results in weight and cost advantages. Low speed model wind tunnel tests of the Mach 2.2 design are described. Active control systems studies are detailed. Status is provided on environmental issues for stratospheric ozone depletion, sonic booms, and airport vicinity emissions. Results of a jet noise suppressor ejector inlet design validation test are given.

*Douglas Aircraft Co., contract NAS1-14624.

51 *Douglas Aircraft Co.: **Technology Application Study of a Supersonic Cruise Vehicle.** NASA CR-159276, 1980.

Aerodynamic, structural, propulsion, and configuration technology integration studies of the Mach 2.2 baseline show significant refinements which improve range performance. Aerodynamic refinements based on the cooperative NASA/MDC high speed wind tunnel model results and structural refinements with the MDC unique titanium superplastic-forming/diffusion-bonding sandwich fabrication technique result in a 15 percent range improvement.

*Douglas Aircraft Co., contract NAS1-14624.

52 *Eriksen, S. E.; and Liu, E. W.: **Effect of Fare and Travel Time on the Demand for Domestic Air Transportation.** NASA CR-159072, 1979. (N79-24972)

An econometric travel demand model is presented. The model was used for analyzing long haul domestic passenger markets in the United States. The results show the sensitivities of demand to changes in fares and speed reflecting technology through more efficient aircraft designs.

*Massachusetts Institute of Technology, contract NAS1-15268.

53 *Espil, Gratien J.: **A Detail Weight Statement for a Typical Mach 2.7 Supersonic Cruise Aircraft Study Configuration.** NASA CR-158975, 1978. (X79-10017)

Synthesized group and detail weight statements are presented in tabular form showing estimated total weight allocated to each major grouping of systems or airframe components for an advanced supersonic technology configuration. The data is presented to serve as a guide for the minimum acceptable level of detail deemed essential to provide adequate weight information during design development, to provide various disciplines involved in conceptual design development with a better insight as to how the predicted weights are distributed, and to aid in the identification of those areas where additional study and ensuing applications of advanced technology concepts would improve the design and either enhance or advance the state of the art.

*Vought Corp., contract NAS1-13500.

54 *Hays, A. P.; and Clauss, J. S., Jr.: **Noise/Cost Sensitivity Studies for a Supersonic Cruise Vehicle With an Over/Under Engine Concept.** NASA CR-158295, 1978. (X79-10085)

The relationship was studied between predicted noise levels at the FAR Part 36 measurement points and predicted direct operating costs (DOC) for an SST with a specified mission, thereby assessing the feasibility of meeting FAR Part 36 (1969) noise requirements and identifying the associated DOC penalties. Various configuration and operational procedures options were applied to a baseline configuration incorporating late 1980's level technology. These options include thrust-weight ratio and wing loading variation, alternate engine cycles, mechanical suppressors, partial power takeoffs, and programmed throttle takeoffs. The cost model uses the ATA 1976 method modified for airline experience and supersonic operations. The noise model considers three sources: jet mixing noise, forward-radiated fan noise, and airframe noise. Results from these analytical predictions indicate that noise levels slightly below FAR 36 (1969) values are achievable for modest DOC penalties. The results show that a combination of noise relief options investigated is required, e.g., variable geometry cycle engine plus inverted flow coannular nozzle plus mechanical suppressor in the high velocity stream combined with a partial power takeoff.

*Lockheed-California Co., contract NAS1-14625.

55 *Kelly, R.; Tyson, R. M.; Dunn, K. M.; Berry, J. V.; Sherrill, D. E.; Lancon, C. J.; Robinson, D. A.; and Cassidy, J. E.: **Study of a Small Supersonic Cruise Research Business Jet.** NASA CR-159226, 1980.

A study was conducted to define a small supersonic cruise vehicle which could validate the critical supersonic cruise technologies. The study involved a comparison of a 1984 state-of-the-art (SOA) multimode integrated propulsion system (MMIPS) and a 1984 SOA GE21 variable cycle engine (VCE) Propulsion system installed in a small supersonic cruise vehicle capable of carrying 8 to 10 passengers. The aircraft were designed for a transatlantic range of 5926 km (3200 n.mi.) with cruise at M = 2.7.

*Rockwell International, contract NAS1-15720.

56 *LTV Aerospace Corp.: **Advanced Supersonic Technology Concept Study Reference Characteristics.** NASA CR-132374, 1973. (N76-71826)

The study results summarized are a critical function of the design mission, ground rules, criteria, and technology used. While every effort has been made to make these studies compatible with previous studies and national objectives, the reader is cautioned that small changes in these parameters can have a large effect on study results. The study results show a considerable increase in the payload and range capability of the Reference Configuration compared with the 1968 Boeing 336C Configuration in spite of more stringent takeoff noise requirements. In addition the Reference Configuration is much less complicated (no folding canard or demand leading edge devices, shorter more simple landing gear) and offers a more desirable five abreast seating arrangement.

*LTV Aerospace Corp., contract NAS1-10900.

57 *Walkley, Kenneth B.; and Martin, Glenn L.: **Aerodynamic Design and Analysis of the AST-200 Supersonic Transport Configuration Concept.** NASA CR-159051, 1979. (N79-22046)

The design and analysis of a supersonic transport configuration was conducted using linear theory methods in conjunction with appropriate constraints. Wing optimization centered on the determination of the required twist and camber and proper integration of the wing and fuselage. Also included in the design are aerodynamic refinements to the baseline wing thickness distribution and nacelle shape. Analysis to the baseline and revised configurations indicated an improvement in lift-to-drag ratio of 0.36 at the Mach 2.7 cruise condition.

*Vought Corp., contract NAS1-13500.

58 *Wright, B. R.; Bruckman, F. A.; Wilson, J. R.; Guinn, W. A.; and Sakata, I. F.: **Supersonic Cruise Vehicle Technology Assessment Study of an Over/Under Engine Concept.** NASA CR-145285, 1977. (X78-10028)

Four distinct areas were studied: planform refinement, engine cycle, noise sensitivity, and structures technology. Two arrow wing planforms were identified which meet low speed requirements while displaying competitive mission performance. More realistic integrated engine/nacelle designs were developed, and the advantages of an integrated digital propulsion control were identified. An optimized aircraft was configured for each engine installation. A noise sensitivity study was initiated to investigate the impact of noise reduction technology on aircraft economics. A low cost titanium manufacturing method utilizing room temperature processing of skin details which features the metastable beta titanium alloy was identified. A superplastic-forming/diffusion-bonding technology application study addressed potential cost and mass savings over current titanium manufacturing techniques. The study of advanced control concepts investigated the feasibility and mass reduction potential of active controls on the supersonic airframe design.

*Lockheed-California Co., contract NAS1-14625.

59 *Wright, B. R.; Clauss, J. S.; Averett, B. T.; Oatway, T. P.; Hays, A. P.; and Sakata, I. F.: **Supersonic Cruise Vehicle Technology Assessment Study of an Over/Under Engine Concept.** NASA CR-159003, 1978. Volume I (X79-10014). Volume II (X79-10015).

Volume I.- The effects of arrow-wing planform geometry variations on airplane low speed handling qualities are investigated using piloted flight simulation techniques. Baseline aircraft engine/airframe integration and installation studies increased aircraft range and defined more realistic engine/nacelle designs. Alternative engine candidates were investigated. Advantages of integrated digital control for engines are identified. A design performance and noise comparison study was conducted on axisymmetric mixed-compression inlets featuring translating and collapsing bicone centerbodies in conjunction with auxiliary inlets. A noise/cost sensitivity study was completed. Parametric aircraft weight estimating methods were further validated for application to arrow-wing designs. Advantages of Ti-15-3 beta alloy over Ti-6-4 alloy was experimentally verified.

Volume II.- This volume contains appendixes to Volume I and presents data and discussion on the following topics: (1) low-speed wind tunnel test L-423; (2) noise/cost sensitivity configuration data; (3) Pratt and Whitney aircraft engines; (4) General Electric Company engines; and (5) jet noise shielding theory.

*Lockheed-California Co., contract NAS1-14625.

60 *Wright, B. R.; and Foss, R. L.: **Technology Assessment Studies Applied to Supersonic Cruise Vehicles.** NASA CR-145133, 1976. (X77-10014)

The study baseline aircraft configuration which incorporates the over/under engine arrangement was refined as a result of new wind tunnel test data input and performance of further airframe planform and propulsion system analyses. The design characteristics, economics, and capabilities of the updated concept were evaluated. A number of alternative engine locations as applied to the baseline aircraft were investigated and compared in terms of impact on aircraft mass, performance, and noise characteristics. A commensurate updated four-engine-under-wing concept was derived. The propulsion studies included continued engine installation losses, engine airflow matching, and engine/airframe integration.

*Lockheed-California Co., contract NAS1-13557.

Articles, Meeting Papers, and Company Reports

61 Baber, Hal T., Jr.; and Driver, Cornelius: **Advanced Supersonic Cruise Aircraft Technology.** Acta Astronaut., vol. 4, no. 1/2, Jan./Feb. 1977, pp. 111-129.

62 Bower, Robert E.: **Future Directions in Aeronautical Research and Technology.** Diamond Jubilee of Powered Flight – The Evolution of Aircraft Design, Jay D. Pinson, ed., American Inst. Aeronaut. & Astronaut., Dec. 1978, pp. 117-131. (In A79-16957)

Available as AIAA Paper 78-3012. (A79-16969)

63 Chacksfield, J. E.: **The Arrow Wing – Its Potentialities and Drawbacks With Regard to In-Flight Aerodynamic Research.** Aircr. Eng., vol. 49, no. 8, Aug. 1977, pp. 4-8.

64 Covault, Craig: **Interest in Supersonic Aircraft Surges.** Aviat. Week & Space Technol., vol. 109, no. 11, Sept. 11, 1978, pp. 109-112.

65 Czysz, Paul: **Supersonic Cruise New Capabilities and Inappropriate Requirements.** McDonnell Douglas paper presented at Conference on the Operational Utility of Supersonic Cruise (Wright-Patterson Air Force Base), Apr. 1977.

66 Densmore, James E.: **Results of Concorde Monitoring.** NOISE-CON 77 Proceedings, George C. Maling, Jr., ed., Noise Control Found., c.1977, pp. 155-164. (In A78-35651)

67 Driver, Cornelius: **Advanced Supersonic Technology and Its Implications for the Future.** AIAA Paper 79-0694, Mar. 1979. (A79-27357)

68 Driver, Cornelius; and Maglieri, Domenic: **Some Unique Characteristics of Supersonic Cruise Vehicles and Their Effect on Airport Community Noise.** AIAA Paper 80-0859, May 1980. (A80-32861)

69 Dubin, A. P.: **Supersonic Transport Market Penetration Model.** AIAA Paper 78-1557, Aug. 1978. (A78-46518)

70 Ferri, Antonio: **Selected Papers on Advanced Design of Air Vehicles.** AGARD-AG-226, Aug. 1977. (N78-10005)

71 Fink, Martin R.: **Noise Component Method for Airframe Noise.** NOISE-CON 77 Proceedings, George C. Maling, Jr., ed., Noise Control Found., c.1977, pp. 397-412. (In A78-35651)

72 FitzSimmons, R. D.: **Technology Readiness for an SST.** AIAA Paper 78-356, Feb. 1978. (A78-24031)

73 FitzSimmons, R. D.; Rowe, W. T.; and Johnson, E. S.: **Advanced Supersonic Transport Engine Integration Studies for Near-Term Technology Readiness Date.** AIAA Paper 78-1052, July 1978. (A78-48487)

74 FitzSimmons, Richard D.: **The Advanced Supersonic Transport: What It Is and How It Compares.** Acta Astronaut., vol. 4, no. 1/2, Jan./Feb. 1977, pp. 131-143.

75 FitzSimmons, Richard D.; and Newton, Floyd C.: **Supersonic Cruise Aircraft – The Potential for Military Roles and Missions.** McDonnell Douglas paper presented at Conference on the Operational Utility of Supersonic Cruise (Wright-Patterson Air Force Base), Apr. 1977.

76 Goodmanson, L. T.; and Sigalla, A.: **The Next SST – What Will It Be?** AIAA Paper 77-797, July 1977. (A77-41960)

77 Kulfan, R. M.; and Sigalla A.: **Real Flow Limitations in Supersonic Airplane Design.** AIAA Paper 78-147, Jan. 1978. (A78-22586)

78 Mack, R. J.; and Darden, C. M.: **Some Effects of Applying Sonic Boom Minimization to Supersonic Cruise Aircraft Design.** AIAA Paper 79-0652, Mar. 1979. (A79-26927)

79 Mijares, R. D.; and Salvagio, J. C.: **Why Fly Supersonically — Flight Time Reduction vs Fuel Consumption and Low Payload.** Paper presented at the 36th Annual Conference of the Society of Allied Weight Engineers (San Diego, Calif.), May 1977. (A78-17889)

80 Peace, M. A.; and Francis, J.: **Some Operational Experience of Concorde Weight and Balance.** SAWE Paper No. 1152, May 1977. (A78-17892)

81 Preisser, J. S.: **Airframe Noise Measurements on a Small-Scale Model of a Supersonic Transport Concept in an Anechoic Flow Facility.** AIAA Paper 79-0666, Mar. 1979. (A79-26920)

82 Schefter, Jim: **New Aerodynamic Design, New Engines, Spawn a Revival of the SST.** Pop. Sci., vol. 215, no. 1, July 1979, pp. 62-65, 129-130.

83 Shimabukuro, K. M.; Welge, H. R.; and Lee, A. C.: **Inlet Design Studies for a Mach 2.2 Advanced Supersonic Cruise Vehicle.** AIAA Paper 79-1814, August 1979. (A79-51247)

84 Sigalla, A.: **Challenges Facing an Advanced U.S. SST Program.** Report D6-46951, Boeing Commercial Airplane Co., July 7, 1978.

85 Sigalla, A.; Runyan, L. J.; and Kane, E. J.: **The Overland Supersonic Transport With Low Sonic Boom — A Feasibility Study.** Acta Aeronaut., vol. 4, no. 1/2, Jan./Feb. 1977, pp. 163-179.

86 Sotomayer, W. A.; and Weeks, T. M.: **Application of a Computer Program System to the Analysis and Design of Supersonic Aircraft.** AIAA Atmospheric Flight Mechanics Conference, Aug. 1977, pp. 90-99. (In A77-43151)

Available as AIAA Paper 77-1131. (A77-43163)

87 Spearman, M. Leroy; and Driver, Cornelius: **Supersonic Flight — Past, Present, and Future.** AIAA Stud. J., vol. 18, no. 1, Spring 1980, pp. 10-19.

88 Wetmore, Warren C.: **Noise Seen Affecting Next SST Design.** Aviat. Week & Space Technol., vol. 108, no. 3, Jan. 16, 1978, pp. 45-54.

89 Wright, B. R.; Bruckman, F.; and Radovcich, N. A.: **Arrow Wings for Supersonic Cruise Aircraft.** AIAA Paper 78-151, Jan. 1978. (A78-22588)

90 Wright, Bruce R.: **Rationale for a Second-Generation Supersonic Transport.** Acta Astronaut., vol. 4, no. 1/2, Jan./Feb. 1977, pp. 145-162.

91 Zorumski, William E.: **Aircraft Flyover Noise Prediction.** NOISE-CON 77 Proceedings, George C. Maling, Jr., ed., Noise Control Found., c.1977, pp. 205-222. (In A78-35651)

SCR PROPULSION

NASA Formal Reports

92 Allan, R. D.; and Johnson, J. E.: **Supersonic Cruise Research Propulsion System Studies — Slide Presentation.** Supersonic Cruise Research '79 — Part 1, NASA CP-2108, 1980, pp. 339-345. (In X80-72343)

The additional flexibility of the single and double bypass features of the variable cycle engine shows a minor degradation in engine removal rate, but improves engine operational cost and manufacturing cost caused by a simple exhaust nozzle. When fuel costs are added, additional payoffs for the single and double bypass features occur. The double bypass feature has the biggest impact on reducing noise at minimum overall cost. It also can match almost any acoustic requirement. Testing of the double bypass VCE should continue and the possibility of simplification should be explored.

93 *Arnaiz, Henry H.; Brownlow, James D.; and Albers, James A.: **A Comparison of Steady-State Performance Among a Flight Inlet on a YF-12 Airplane and Two Wind Tunnel Models Using Statistical Techniques.** YF-12 Experiments Symposium — Volume 3, NASA CP-2054, 1978, pp. 187-292. (In X79-72834)

A comparison was made between the steady-state performance of a flight inlet on a YF-12 airplane and a full-scale and a one-third-scale wind tunnel model of the same inlet. The purpose of the comparison was to determine whether performance differences were present between flight and wind tunnel models when operated over a Mach number range where the inlets were in the mixed-compression mode. Identical test conditions could not be obtained because of limitations encountered in the testing of the three inlets. Little or no differences were present between the performance of the flight inlet and the two wind tunnel models.
*Classified.

94 Atencio, Adolph, Jr.: **The Effect of Forward Speed on J85 Engine Noise From Suppressor Nozzles as Measured in the NASA-Ames 40- by 80-Foot Wind Tunnel.** NASA TN D-8426, 1977. (N77-17068)

An investigation to determine the effect of forward speed on the exhaust noise from a conical ejector nozzle and three suppressor nozzles mounted behind a J85 engine was performed in a 40- by 80-foot wind tunnel. The nozzles were tested at three engine power settings and at wind tunnel forward speeds up to 21 m/sec (200 ft/sec). In addition, outdoor static tests were conducted to determine (1) the differences between near field and far field measurements, (2) the effect of an airframe on the far field directivity of each nozzle, and (3) the relative suppression of each nozzle with respect to the baseline conical ejector nozzle. It was found that corrections to near field data are necessary to extrapolate to far field data and that the presence of the airframe changed the far field directivity as measured statically. The results show that the effect of forward speed was to reduce the noise from each nozzle more in the area of peak noise, but the change in forward quadrant noise was small or negligible. A comparison of wind tunnel data with available flight test data shows good agreement.

95 Bangert, L. H.; Santman, D. M.; Horie, G.; and Miller, L. D.: **Effects of Inlet Technology on Cruise Speed Selection.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 391-411. (In X80-72343)

Recently Lockheed has studied the impact of cruise speed on technology level for certain supersonic cruise research (SCR) aircraft components. In the present study, external-compression inlets were compared with mixed-compression, self-starting inlets at cruise Mach numbers of 2.0 and 2.3. Inlet-engine combinations that provided the greatest aircraft range were identified. Results showed that increased transonic-to-cruise corrected air flow ratio gave decreased range for missions dominated by supersonic cruise. It was also found important that inlets be designed to minimize spillage drag at subsonic cruise, because of the need for efficient performance for overland operations. The external-compression inlet emerged as the probable first choice at Mach 2.0, while the self-starting inlet was the probable first choice at Mach 2.3. Airframe-propulsion system interference effects were significant, and further study is needed to assess the existing design methods and to develop improvements.

96 *Brownlow, James D.; Arnaiz, Henry H.; and Albers, James A.: ***Mathematical Modeling of the* Performance of a YF-12 Mixed-Compression Inlet by Using Multiple Regression Techniques.** YF-12 Experiments Symposium – Volume 3, NASA CP-2054, 1978, pp. 115-186. (In X79-72834)

A mathematical model to correlate wind tunnel and flight performance data of a high-speed, mixed-compression inlet was derived from a set of wind tunnel test data. A multiple regression technique, which basically uses a least-squares method to fit equations to the data, was used to derive the model. The mathematical model was evaluated using both a mathematical (statistical) and an engineering approach. Results indicated that the model could predict the wind tunnel results.
*Classified.

97 *Cole, G. L.; Sanders, B. W.; and Neiner, G. H.: **Wind-Tunnel Performance of a YF-12 Aircraft Flight Inlet Modified by Various Stability-Bypass Porous-Bleed Configurations.** NASA TM-73801, 1979. (X79-10167)

The purpose of stability bleed is to allow higher performance of mixed-compression inlets while maintaining a substantial tolerance (without unstart) to internal (e.g., engine) and external (e.g., angle of attack) flow field perturbations. Stability-bleed airflow was removed through a porous bleed region in the cowl surface just upstream of the inlet shock trap. Ultimately, the system was to use two circumferential rows of relief-type mechanical valves to control bleed-plenum exit area and hence stability-bleed airflow. A bleed configuration that would reasonably match the pressure-airflow characteristics of the valves was investigated so that the system could be demonstrated in flight. Steady-state results are presented for four stability-bypass bleed configurations. With the valves simulated closed, the inlet steady-state performance is about the same as that of the unmodified inlet.

*Classified.

98 Cole, Gary L.: **Atmospheric Effects on Inlets for Supersonic Cruise Aircraft.** NASA TM X-73647, 1977. (N78-10026)

Mixed-compression inlet dynamic behavior in the vicinity of unstart was simulated and analyzed to investigate time response of an inlet's normal shock to independent disturbances in ambient temperature and pressure and relative velocity (longitudinal gust), with and without inlet controls active. The results indicate that atmospheric disturbances may be more important than internal disturbances in setting inlet control requirements because they are usually not anticipated and because normal shock response to rapid atmospheric disturbances is not attenuated by the inlet, as it is for engine induced disturbances. However, before inlet control requirements can be fully assessed, more statistics on extreme atmospheric disturbances are needed.

99 *Cole, Gary L.; Dustin, Miles O.; and Neiner, George H.: **Wind-Tunnel Performance of a Throat-Bypass Stability System for the YF-12 Inlet.** Y-12 Experiments Symposium — Volume 2, NASA CP-2054, 1978, pp. 71-106. (In X79-10157)

The basic concept has been demonstrated with wind-tunnel models. A YF-12 aircraft inlet was modified so that stability-bleed airflow could be removed through a porous cowl-bleed region just upstream of the inlet's shock trap. Wind-tunnel development of the stability-bleed pattern is discussed, and steady-state inlet and bleed performance data are presented. The results of this investigation show that (1) the stability system can absorb diffuser-exit airflow disturbances that are too fast for the inlet's control system and that the two systems complement each other and (2) the stability system provides increased tolerance to transients in angle of attack and spike-tip Mach number and provides additional time for the inlet control system to respond.

*Classified.

100 Cole, Gary L.; and Hingst, Warren R.: **Investigation of Means for Perturbing the Flow Field in a Supersonic Wind Tunnel.** NASA TM-78954, 1978. (N78-27142)

The development status of a device for generating atmospheric-type turbulences in supersonic inlet testing is summarized. Elaborated are desired aerodynamic and actuation capabilities of the device and the techniques that were considered and their drawbacks.

101 Cole, Gary L.; Neiner, George H.; and Dustin, Miles O.: **Wind Tunnel Evaluation of YF-12 Inlet Response to Internal Airflow Disturbances With and Without Control.** YF-12 Experiments Symposium — Volume 1, NASA CP-2054, 1978, pp. 157-192. (In N78-32055)

The response of terminal-shock position and static pressures in the subsonic duct of a YF-12 aircraft flight-hardware inlet to perturbations in simulated engine corrected airflow was obtained with and without inlet control. Frequency response data, obtained with inlet controls inactive, indicated the general nature of the inherent inlet dynamics, assisted in the design of controls, and provided a baseline reference for responses with active controls. All the control laws were implemented by means of a digital computer that would be programmed to behave like the flight inlet's existing analog control. The experimental controls were designed using an analytical optimization technique. The capabilities of the controls were limited primarily by the actuation hardware. The experimental controls provided somewhat better attenuation of terminal shock excursions than did the YF-12 inlet control. Controls using both the forward and aft bypass systems also provided somewhat better attenuation than those using only the forward bypass. The main advantage of using both bypasses is in the greater control flexibility that is achieved.

102 *Cubbison, Robert W.; and Sanders, Bobby W.: **Comparison of One-Third Scale and Full-Scale YF-12 Isolated Inlet Performance.** YF-12 Experiments Symposium — Volume 3, NASA CP-2054, 1978, pp. 87-113. (In X79-72834)

Steady-state data obtained on a one-third-scale isolated inlet model tested in the Ames Research Center Unitary Plan Wind Tunnel Complex 9- by 7-Foot and 8- by 7-Foot Supersonic Wind Tunnels and on a full-scale flight inlet tested in the Lewis Research Center 10- by 10-Foot Supersonic Wind Tunnel are presented for Mach numbers above 2.0. Performance levels are compared for nominal standard day and peak operating conditions. Unstart boundaries and the effect of angle of attack are discussed.

*Classified.

103 *Cubbison, Robert W.; and Sanders, Bobby W.: **Full-Scale YF-12 Inlet Calibration and Flow System Interactions.** YF-12 Experiments Symposium – Volume 3, NASA CP-2054, 1978, pp. 55-86. (In X79-72834)

The isolated, full-scale, flight hardware inlet was tested in the Lewis Research Center 10- by 10-Foot Supersonic Wind Tunnel to provide the calibrations necessary for flight data reduction and to establish inlet operating boundaries which in turn determined the flight test conditions. The scope and results of the calibration are presented as well as the inlet flow system interactions. The inlet operating envelope showing the unstart-restart boundaries is presented.

*Classified.

104 Fishbach, Laurence H.: **Preliminary Study of Optimum Ductburning Turbofan Engine Cycle Design Parameters for Supersonic Cruising.** NASA TM-79047, 1978. (N79-12083)

The effect of turbofan engine overall pressure ratio, fan pressure ratio, and duct burner temperature rise on the engine weight and cruise fuel consumption for a Mach 2.4 supersonic transport was investigated. Design point engines, optimized purely for the supersonic cruising portion of the flight where the bulk of the fuel is consumed, are considered. Based on constant thrust requirements at cruise, fuel consumption considerations would favor medium bypass ratio engines (1.5 to 1.8) of overall pressure ratio of about 16. Engine weight considerations favor low bypass ratio (0.6 or less) and low overall pressure ratio (8). Combination of both effects results in bypass ratios of 0.6 to 0.8 and an overall pressure ratio of 12 being the overall optimum.

105 FitzSimmons, R. D.; McKinnon, R. A.; and Johnson, E. S.: **Flight and Tunnel Test Results of the MDC Mechanical Jet Noise Suppressor Nozzle.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 453-478. (In X80-72343)

The flight test program was jointly sponsored by McDonnell Douglas Corporation (MDC), Rolls-Royce, Ltd. (RR), British Aerospace (BAe), and the Royal Aircraft Establishment (RAE). To simulate a supersonic transport engine, Rolls Royce supplied a unique uprated Viper engine. Data were recorded from more than 400 passes of the HS-125 test aircraft. Seven nozzle configurations – including two reference nozzles, two suppressors, and three ejector inlets – were tested. The suppressor nozzle of interest for an advanced supersonic transport (AST), the MDC suppressor/treated ejector, achieved a measured noise reduction of 14 EPNdB relative to a conventional conical reference nozzle. The wind tunnel test program was jointly sponsored by NASA, MDC, RR, and BAe. The unique engine nacelle, flight hardware, and nacelles from the HS-125 flight test program combined with a simulated HS-125 fuselage were tested in the NASA Ames 40 × 80 foot wind tunnel and in the outdoor Ames test facility. The test results indicate that a noise reduction of at least 16 EPNdB would be possible for the MDC suppressor/ejector nozzle scaled to typical AST engine size with a 5 percent thrust loss at a typical takeoff climb speed.

106 Franciscus, Leo C.: **Supersonic Through-Flow Fan Engines for Supersonic Cruise Aircraft.** NASA TM-78889, 1978. (N78-23088)

Engine performance, weight, and mission studies were carried out for supersonic through-flow fan engine concepts. The mission used was a Mach 2.32 cruise mission. The advantages of supersonic through-flow fan engines were evaluated in terms of mission range comparisons between the supersonic through-flow fan engines and a more conventional turbofan engine. The specific fuel consumption of the supersonic through-flow fan engines was 12 percent lower than the more conventional turbofan. The aircraft mission range was increased by 20 percent with the supersonic fan engines compared to the conventional turbofan.

107 Groesbeck, Donald E.; Huff, Ronald G.; and Von Glahn, Uwe H.: **Comparison of Jet Mach Number Decay Data With a Correlation and Jet Spreading**

Contours for a Large Variety of Nozzles. NASA TN D-8423, 1977. (N77-28087)

Small-scale circular, noncircular, single- and multi-element nozzles with flow areas as large as 122 cm^2 were tested with cold airflow at exit Mach numbers from 0.28 to 1.15. The effects of multi-element nozzle shape and element spacing on jet Mach number decay were studied in an effort to reduce the noise caused by jet impingement on externally blown flap (FRE) STOL aircraft. The jet Mach number decay data are well represented by empirical relations. Jet spreading and Mach number decay contours are presented for all configurations tested.

108 Hunt, Richard B.; and Howlett, Robert A.: **Variable Stream Control Engine for Advanced Supersonic Aircraft Design Update.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 357-370. (In X80-72343)

The Pratt and Whitney Aircraft study engine concept for a second-generation supersonic transport, the Variable Stream Control Engine (VSCE), has been updated in terms of mechanical design definition and estimated performance. The design definition reflects technology advancements projected for the late 1980 time period that improve system efficiency, durability, and environmental performance. Technology requirements were established. The components unique to the VSCE concept, a high performance duct burner and a low noise coannular nozzle, and the high temperature components are identified as critical technologies. Technology advances for the high temperature components (main combustor and turbines) are not exclusive to the VSCE, but are equally applicable to any advanced supersonic propulsion system whether a low bypass engine, inverted flow engine, or other variable cycle engine configuration. The technical approach for undertaking a High Temperature Validation Program has been defined. The multi-phased effort would culminate with the demonstration of a flight-type main combustor and single-stage high-pressure turbine at operating conditions envisioned for a VSCE.

109 Knott, Paul R.; Brausch, J. F.; Bhutiani, P. K.; Majjigi, R. K.; and Doyle, V. L.: **VCE Early Acoustic Test Results of General Electric's High-Radius Ratio Coannular Plug Nozzle.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 417-452. (In X80-72343)

Results of NASA Lewis Research Center/General Electric Company Variable Cycle Engine (VCE) early acoustic engine and model scale tests are presented. Extensive series of far-field acoustic, advanced acoustic, and exhaust plume velocity measurements with a laser velocimeter of inverted velocity and temperature profile, high-radius-ratio coannular plug nozzles on a YJ101 VCE static engine test vehicle are reviewed. Select model scale simulated flight acoustic measurements for an unsuppressed and a mechanical suppressed coannular plug nozzle are also discussed. The engine acoustic nozzle tests verify previous model scale noise reduction measurements. The engine measurements show 4-6 PNdB aft quadrant jet noise reduction and up to 7 PNdB forward quadrant shock noise reduction relative to a fully mixed conical nozzle at the same specific thrust and mixed pressure ratio. The influences of outer nozzle radius ratio, inner stream velocity ratio, and area ratio are discussed. Coannular suppression is maintained in forward speed. The outlook for achieving jet noise abatement levels for high performance supersonic aircraft on the order of current subsonic commercial vehicles is discussed.

110 Maestrello, Lucio: **Initial Results of a Porous Plug Nozzle for Supersonic Jet Noise Suppression.** NASA TM-78802, 1978. (N79-13820)

As part of a continuing study of possible methods of jet noise reduction, some tests have been made on a porous plug type noise suppressor. Very little information exists on the aeroacoustic performance of jet nozzles having porous elements designed to eliminate the shock wave in the exhaust stream and by so doing to eliminate the shock-associated noise and screech. Some initial results on the aeroacoustic performance of a model porous plug type jet noise suppressor are presented. Included are shadowgraph pictures of the flow exhausting from the porous plug nozzle with the comparable acoustic far field spectra and cross-correlations which illustrate the benefits of the test device.

111 Morris, Shelby J.: **Computer Program for the Design and Off-Design Performance of Turbojet and Turbofan Engine Cycles.** NASA TM-78653, 1978. (N78-30122)

The rapid computer program is designed to be run in a stand-alone mode or operated within a larger program. The computation is based on a simplified one-dimensional gas turbine cycle. Each component in the engine is modeled thermodynamically. The component efficiencies used in the thermodynamic modeling are scaled for the off-design conditions from input design point values using empirical trends which are included in the computer code. The engine cycle program is capable of producing reasonable engine performance prediction with a minimum of computer execution time. The current computer execution time on the IBM 360/67 for one Mach number, one altitude, and one power setting is about 0.1 second. The principal assumption used in the calculation is that the compressor is operated along a line of maximum adiabatic efficiency on the compressor map. The fluid properties are computed for the combustion mixture, but dissociation is not included. The procedure included in the program is only for the combustion of JP-4, methane, or hydrogen.

112 Neiner, George H.; Dustin, Miles O.; and Cole, Gary L.: **Mechanical Characteristics of Stability-Bleed Valves for a Supersonic Inlet.** NASA TM X-3483, 1977. (N78-13063)

Mechanical characteristics of a set of direct-operated relief valves used in a throat-bypass stability-bleed system designed for the YF-12 aircraft inlet are described. A comparison of data taken before and after the wind-tunnel tests (at room temperature) showed that both the effective spring rate and the piston friction had decreased during the wind-tunnel tests. In neither the effective spring rate nor the piston friction was the magnitude of change great enough to cause significant impairment of overall system effectiveness. No major valve mechanical problems were encountered in any of the tests. During high temperature bench tests, piston frictional drag increased. The friction returned to its initial room temperature value when the stability-bleed valve was disassembled and reassembled. The problem might be solved by using a different material for the piston sleeve bearing and the piston rings.

113 Neiner, George H.; Dustin, Miles O.; and Cole, Gary L.: **A Throat-Bypass Stability-Bleed System Using Relief Valves To Increase the Transient Stability of a Mixed-Compression Inlet.** NASA TP-1083, 1979. (N79-28176)

A stability-bleed system was installed in a YF-12 flight inlet that was subjected to internal and external airflow disturbances in the NASA Lewis 10 by 10 foot supersonic wind tunnel. The purpose of the system is to allow higher inlet performance while maintaining a substantial tolerance (without unstart) to internal and external disturbances. At Mach numbers of 2.47 and 2.76, the inlet tolerance to decreases in diffuser-exit corrected airflow was increased by approximately 10 percent of the operating-point airflow. The stability-bleed system complemented the terminal-shock-control system of the inlet and did not show interaction problems. For disturbances which caused a combined decrease in Mach number and increase in angle of attack, the system with valves operative kept the inlet started 4 to 20 times longer than with the valves inoperative. Hence, the stability system provides additional time for the inlet control system to react and prevent unstart. This was observed for initial Mach numbers of 2.55 and 2.68. For slow increases in angle of attack at Mach 2.47 and 2.76, the system kept the inlet started beyond the steady-state unstart angle. However, the maximum transient angles of attack without unstart could not be determined because wind-tunnel mechanical-stop limits for angle of attack were reached.

114 Pao, S. Paul: **A Correlation of Mixing Noise From Coannular Jets With Inverted Flow Profiles.** NASA TP-1301, 1979. (N79-22849)

Data are correlated for jet mixing noise from coannular jets with inverted flow velocity profiles. The acoustic performance of coannular jets is compared to the performance of a hypothetical single jet with the same total mass flow, thrust, and total enthalpy flow as the coannular jet. The study shows that coannular jets with velocity ratios greater than 1.2 produce less noise than their corresponding equivalent tests and that optimum noise reduction of coannular jets in the data set occurs within a range of equivalent velocities between 500 and 700 meters per second and velocity ratios between 1.6 and 2.3. The maximum sound power reduction is found to be about 4 decibels. Directivity indices and a special set of spectral curves were developed to describe the characteristic double peak spectra of coannular jet noise. The temperature ratio between the inner and outer streams was not found to be important in this acoustic correlation. However, the mean temperature effect was included in the computations of sound pressure levels.

115 *Reukauf, Paul J.; Olinger, Frank V.; Ehernberger, L. J.; and Yanagidate, Craig: **Flight-Measured Transients Related to Inlet Performance on the YF-12 Airplane.** YF-12 Experiments Symposium — Volume 3, NASA CP-2054, 1978, pp. 427-473. (In X79-72834)

As part of the YF-12 experiments program, the response of the inlet and inlet control system to transient phenomena was investigated in flight. A four-part study addressed characteristics associated with (1) the pressure frequency response of the inlet, (2) the effects of compressor stalls, (3) the response to inlet unstarts, and (4) the effects of free stream turbulence.

*Classified.

116 Roberts, Peter B.; and Butze, Helmut F.: **Advanced Low-NO_x Combustors for Supersonic High-Altitude Gas Turbines.** Aircraft Engine Emissions, NASA CP-2021, 1977, pp. 393-415. (In N78-11063)

Two combustor concepts have been reevaluated, with the major stress placed on screening of techniques that will allow these combustors to operate with satisfactory emissions at the engine idle condition and thus across the complete range of entire conditions. This paper describes the combustor concepts investigated and summarizes the test results obtained during the follow-on program.

117 *Schweikhard, William G.; and Campbell, David H.: **An Introduction and Summary of the YF-12 Propulsion Research Program.** YF-12 Experiments Symposium — Volume 3, NASA CP-2054, 1978, pp. 7-54. (In X79-72834)

An overview of the YF-12 propulsion research program, its objectives, and some of the considerations and obstacles involved in carrying it out are presented. A description of the propulsion system, its controls and operating characteristics, and some highlights of previously unpublished results are included. Insights and pitfalls associated with a program whose prime objective was the correlation of analytical, wind tunnel, and flight results are presented.

*Classified.

118 Seiner, John M.; Norum, Thomas D.; and Maestrello, Lucio: **Effects of Nozzle Design on the Noise From Supersonic Jets.** Supersonic Cruise Research '79 — Part 1, NASA CP-2108, 1980, pp. 479-491. (In X80-72343)

The aeroacoustic supersonic performance of various internal nozzle geometries is evaluated for shock noise content over a wide range of nozzle pressure ratios. The noise emission of a Mach 1.5 and 2.0 convergent-divergent (C-D) nozzle is measured and compared to convergent nozzles. Comparisons are also made for a Mach 1.5 conical C-D nozzle and a porous plug nozzle. The Mach 1.5 conical C-D nozzle shows a small reduction in shock noise relative to the shock free case of the Mach 1.5 C-D nozzle. The Mach 1.5 C-D nozzle is found to have a wide operating nozzle pressure ratio range around its design point where shock noise remains unimportant compared to the jet mixing noise component. However, it is found that the Mach 2 C-D nozzle shows no significant acoustic benefit relative to the convergent nozzle. Results from the porous plug nozzle indicate that shock noise may be completely eliminated, and the jet mixing noise reduced.

119 Stone, James R.: **An Empirical Model for Inverted-Velocity-Profile Jet Noise Prediction.** NASA TM-73838, 1977. (N78-13061)

An empirical model for predicting the noise from inverted-velocity-profile coaxial or coannular jets is presented and compared with small-scale static and simulated flight data. The model considered the combined contributions of as many as four uncorrelated constituent sources: the premerged-jet/ambient mixing region, the merged-jet/ambient mixing region, outer-stream shock/turbulence interaction, and inner-stream shock/turbulence interaction. The noise from the merged region occurs at relatively low frequency and is modeled as the contribution of a circular jet at merged conditions and total exhaust area, with the high frequencies attenuated. The noise from the premerged region occurs at high frequency and is modeled as the contribution of an equivalent plug nozzle at outer-stream conditions, with the low frequencies attenuated.

120 Stone, James R.: **An Improved Method for Predicting the Effects of Flight on Jet Mixing Noise.** NASA TM-79155, 1979. (N79-24770)

The NASA method (1976) for predicting the effects of flight on jet mixing noise was improved. The earlier method agreed reasonably well with experimental flight data for jet velocities up to about 520 m/sec (approximately 1700 ft/sec). The poorer agreement at high jet velocities appeared to be due primarily to the manner in which supersonic convection effects were formulated. The purely empirical supersonic convection formulation of the earlier method was replaced by one based on theoretical considerations. Other improvements included of an empirical nature were based on model-jet/free-jet simulated flight tests. The revised prediction method is presented and compared with experimental data obtained from the Bertin Aerotrain with a J85 engine, the DC-10 airplane with JT9D engines, and the DC-9 airplane with refanned JT8D engines. It is shown that the new method agrees better with the data base than a recently proposed SAE method.

121 Stone, James R.: **On the Use of Relative Velocity Exponents for Jet Engine Exhaust Noise.** NASA TM-78873, 1978. (N78-24137)

The effect of flight on jet engine exhaust noise has often been presented in terms of a relative velocity exponent, n, as a function of radiation angle. The value of n is given by the OASPL reduction due to relative velocity divided by 10 times the logarithm of the ratio of relative jet velocity to absolute jet velocity. In such terms, classical subsonic jet noise theory would result in a value of n being approximately 7 at a 90^{o} angle to the jet axis with n decreasing, but remaining positive, as the inlet axis is approached and increasing as the jet axis is approached. However, flight tests have shown a wide range of results, including negative values of n in some cases. In this paper it is shown that the exponent n is positive for pure subsonic jet mixing noise and varies, in a systematic manner, as a function of flight conditions and jet velocity.

122 Stone, James R.; and Montegani, Francis J.: **An Improved Prediction Method for the Noise Generated in Flight by Circular Jets.** NASA TM-81470, 1980. (N80-22048)

A semi-empirical model for predicting the noise generated by jets exhausting from circular nozzles is presented and compared with small-scale static and simulated-flight data. The present method is an updated version of that part of the original NASA Aircraft Noise Prediction Program (1974) relating to circular jet noise. The earlier method has been shown to agree reasonably well with experimental static and flight data for jet velocities up to ~520 m/sec. The poorer agreement at higher jet velocities appeared to be due primarily to the manner in which supersonic convection effects were formulated. The purely empirical supersonic convection formulation is replaced in the present method by one based on theoretical considerations. Other improvements of an empirical nature have been included based on model-jet/free-jet simulated-flight tests. The effects of nozzle size, jet velocity, jet temperature, and flight are included.

123 Vdoviak, J. W.; and Ebacher, J. A.: **VCE Test Bed Engine for Supersonic Cruise Research.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 347-356. (In X80-72343)

General Electric initiated a broad investigative variable cycle demonstrator engine test program in 1976, utilizing the YJ101 engine as the basic vehicle. This program is aimed at evaluating variable cycle concepts applicable to a supersonic, mixed mission propulsion system which would combine the merits of a turbofan at subsonic operating conditions with those of a turbojet for supersonic operating conditions. Over the last four-year period, five sequential VCE demonstrator tests have been accomplished under combined U.S. Air Force, U.S. Navy, and NASA auspices in a uniquely cooperative and complementary test program.

124 Westmoreland, John S.: **Progress With Variable Cycle Engines.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 371-390. (In X80-72343)

Under NASA sponsorship, Pratt and Whitney Aircraft has been evaluating and substantiating two of the most critical and unique components of an advanced propulsion system for a future supersonic cruise vehicle. These components, a high performance duct burner for thrust augmentation and a low jet noise coannular exhaust nozzle, are part of the Variable Stream Control Engine (VSCE). Studies have identified this engine as having the greatest potential for an advanced supersonic commercial cruise vehicle, when considering the overall environmental and economic requirements. An experimental test program involving both isolated component and complete engine tests has been conducted for the high performance, low emissions duct burner with excellent results. Nozzle model tests have also been completed which substantiate the inherent jet noise benefit associated with the unique velocity profile possible of a coannular exhaust nozzle system on a Variable Stream Control Engine. Additional nozzle model performance tests have established high thrust efficiency levels at takeoff and supersonic cruise for this nozzle system. Large scale testing of these two critical components is being conducted using an F100 engine as the testbed for simulating the Variable Stream Control Engine.

NASA Contractor Reports

125 *Ahuja, K. K.; Tester, B. J.; and Tanna, H. K.: **The Free Jet as a Simulator of Forward Velocity Effects on Jet Noise.** NASA CR-3056, 1978. (N79-14873)

A thorough theoretical and experimental study of the effects of the free-jet shear layer on the transmission of sound from a model jet placed within the free jet to the far-field receiver located outside the free-jet flow was conducted. The validity and accuracy of the free-jet flight simulation technique for forward velocity effects on jet noise were evaluated. Transformation charts and a systematic computational procedure for converting measurements from a free-jet simulation to the corresponding results from a wind-tunnel simulation, and, finally, to the flight case, were provided. The effects of simulated forward flight on jet mixing noise, internal noise, and shock-associated noise from model-scale unheated and heated jets were established experimentally in a free-jet facility. It was illustrated that the existing anomalies between full-scale flight data and model scale flight simulation data projected to the flight case could well be due to the contamination of flight data by engine internal noise.

*Lockheed-Georgia Co., contract NAS3-20050.

126 *Allan, R. D.: **Advanced Supersonic Propulsion Studies — Final Report 1977.** NASA CR-159321, 1977.

This subcontract from the Douglas Aircraft Company, McDonnell Douglas Corporation, provided propulsion support for the Douglas NASA Langley SCR Studies. Supersonic cruise engines matched to the Douglas Mach 2.2 supersonic cruise commercial airplane were supplied in two levels of technology and for different engine cycles. Low bypass turbofan engines were provided for near term (1978-1979) technology and for advanced (1982-1985) technology. These engines were designed to show the improvements provided by advanced technology, such as high turbine inlet temperatures, advanced turbine cooling techniques, and advanced materials for both static and rotating parts. In addition to the turbofan engines, a double bypass variable cycle engine (VCE), also utilizing advanced (1982-1985) technology was provided to show the benefits to the airplane of an advanced variable cycle engine concept.

*General Electric Co., contract NAS1-14624.

127 *Allan, R. D.: **Advanced Supersonic Propulsion Studies — Final Report 1978.** NASA CR-159322, 1978.

Studies were conducted for Douglas Aircraft Company to provide propulsion system support for their Supersonic Cruise Vehicle Studies under contract from NASA Langley Research Center. Refined versions of both the single bypass (GE21/J10B7) and double bypass (GE21/J11B18) variable cycle engines were furnished to Douglas. These engines were designed to better match the Douglas airplane and provide improved range at the design gross weight.

*General Electric Co., contract NAS1-14624.

128 *Allan, R. D.: **Definition Study of a Variable Cycle Experimental Engine (VCEE) and Associated Test Program and Test Plan.** NASA CR-159419, 1978. (N79-11042)

The definition study of a Variable Cycle Experimental Engine (VCEE) and Associated Test Program and Test Plan was initiated to identify the most cost effective program for a follow-on to the AST Test Bed Program. The VCEE Study defined various subscale VCE's based on different available core engine components, and a full scale VCEE utilizing current technology. The cycles were selected, preliminary design accomplished, and program plans and engineering costs developed for several program options. In addition to the VCEE program plans and options, a limited effort was applied to identifying programs that could logically be accomplished on the AST Test Bed Program

VCE to extend the usefulness of this test hardware. Component programs were provided that could be accomplished prior to the start of a VCEE Program.

*General Electric Co., contract NAS3-20810.

129 *Allan, Roy D.; and Joy, Warren: **Advanced Supersonic Propulsion Technology Study — Phases III and IV.** NASA CR-135236, 1977. (N78-13058)

An evaluation of various advanced propulsion concepts for supersonic cruise aircraft resulted in the identification of the double-bypass variable cycle engine as the most promising concept. This engine design utilizes special variable geometry components and an annular exhaust nozzle to provide high take-off thrust and low jet noise. The engine also provides good performance at both supersonic cruise and subsonic cruise. Emission characteristics are excellent. The advanced technology double-bypass variable cycle engine offers an improvement in aircraft range performance relative to earlier supersonic jet engine designs and yet at a lower level of engine noise. Research and technology programs required in certain design areas for this engine concept to realize its potential benefits include refined parametric analysis of selected variable cycle engines, screening of additional unconventional concepts, and engine preliminary design studies. Required critical technology programs are summarized.

*General Electric Co., contract NAS3-19544.

130 *Blankenship, G. L.; Low J. K. C.; Watkins, J. A.; and Merriman, J. E.: **Effect of Forward Motion on Engine Noise.** NASA CR-134954, 1977. (N78-10093)

Methods used to determine a procedure for correcting static engine data for the effects of forward motion are described. Data were analyzed from airplane flyover and static-engine tests with a JT8D 109 low-bypass-ratio turbofan engine installed on a DC-9-30, with a CF6-6D high-bypass-ratio turbofan engine installed on a DC-10-40. The observed differences between the static and the flyover data bases are discussed in terms of noise generation, convective amplification, atmospheric propagation, and engine installation. The results indicate that each noise source must be adjusted separately for forward-motion and installation effects and then projected to flight conditions as a function of source-path angle, directivity angle, and acoustic range relative to the microphones on the ground.

*Douglas Aircraft Co., contract NAS3-20031.

131 *Colley, W. C.; Kenworthy, M. J.; and Bahr, D. W.: **Augmented Emissions Reduction Technology Program.** NASA CR-135215, 1977. (N78-13057)

Technology to reduce pollutant emissions from duct-burner-type augmentors for use on advanced supersonic cruise aircraft was investigated. Test configurations, representing variations of two duct burner design concepts, were tested in a rectangular sector rig at inlet temperature and pressure conditions corresponding to takeoff, transonic climb, and supersonic cruise flight conditions. Both design concepts used piloted flameholders to stabilize combustion of lean, premixed fuel/air mixtures. The concepts differed in the flameholder type used. High combustion efficiency (97 percent) and low levels of emissions (1.19 g/kg fuel) were achieved. The detailed measurements suggested the direction that future development efforts should take to obtain further reductions in emission levels and associated improvements in combustion efficiency over an increased range of temperature rise conditions.

*General Electric Co., contract NAS3-19737.

132 *Douglas Aircraft Co.: **Cooperative Wind Tunnel Tests of Douglas Advanced Supersonic Technology Jet Noise Suppressor.** NASA CR-158996, 1978. (X79-10084)

An experimental program was conducted on a model scale 15.24 cm (6 in.) equivalent diameter conical reference nozzle and a 12-lobe/24-tube mechanical jet noise suppressor nozzle to determine flight effects on jet noise. The nozzles were tested with and without an acoustically treated ejector in an outdoor static facility at NASA Ames Research Center and in the Ames 40 by 80 ft wind tunnel. Data which were taken in both facilities on three near field sidelines are used to identify jet noise source locations and radiation angles. Outdoor static test data also include far field measurements. Outdoor near field data projected to the far field sideline are compared with the far field sideline measurements to determine empirical adjustments to permit the wind tunnel near field data to be extrapolated to the far field. Flight effects are determined from the wind tunnel data projected to the far field and converted to a full scale equivalent diameter of 95.25 cm (37.5 in.). The converted full scale data extrapolated to a typical flyover distance indicate that the measured noise levels of the conical reference nozzle decrease with forward flight and are about 5 PNdB lower at a Mach number of 0.28. The measured noise levels of the 12-lobe/24-tube suppressor/treated ejector configuration, converted to full scale, decrease in a similar manner. The resulting jet noise reduction of the mechanical suppressor ejector is apparently independent of flight speed. Some nozzle coefficient data obtained previously are included.

*Douglas Aircraft Co., contract NAS1-14601.

133 *Heck, P. H.; Latham, D.; Brausch, J. F.; Stringas, E. J.; Staid, P. S.; and Knott, P. R.: **Acoustic Tests of Duct-Burning Turbofan Jet Noise Simulation — Comprehensive Data Report.** NASA CR-135239, [1978].

Volume I, Section I.- Model Scale Data. (N78-28094)

Model scale data on a 12.2 m (40 ft) arc are presented which were obtained in the hot, static acoustic tests on eleven nozzle designs suitable for use on duct-burning turbofan engines.

Volume I, Section II.- Full Size Data. (N78-28095)

Acoustic data are presented scaled to a full size engine by a factor of 8 on a 96.9 m (320 ft) arc and a 731.5 m (2400 ft) sideline.

Volume I, Section III.- Data Plots. (N78-28096)

Acoustic data plots are presented which were obtained in the tests on scale nozzles for use on duct-burning turbofan engines.

Volume II.- Model Design and Aerodynamic Test Results. (N78-28097)

The selection procedure is described which was used to arrive at the configurations tested, and the performance characteristics of the test nozzles are given.

*General Electric Co., contract NAS3-18008.

134 *Hersh, Alan S.; and Walker, Bruce: **Effect of Grazing Flow on the Acoustic Impedance of Helmholtz Resonators Consisting of Single and Clustered Orifices.** NASA CR-3177, 1979. (N79-32056)

A semiempirical fluid mechanical model is derived for the acoustic behavior of thin-walled single orifice Helmholtz resonators in a grazing flow environment. The incident and cavity sound fields are connected in terms of an orifice discharge coefficient whose values are determined experimentally using the two microphone method. Measurements show that at high grazing flow speeds, acoustical resistance is almost linearly proportional to the grazing flow speed and almost independent of incident sound pressure. The corresponding values of reactance are much smaller and tend toward zero. For thicker walled orifice plates, resistance and reactance were observed to be less sensitive to grazing flow as the ratio of plate thickness to orifice diameter increased. Loud tones were observed to radiate from a single orifice Helmholtz resonator due to interaction between the grazing flow shear layer and the resonator cavity. Measurements showed that the tones radiated at a Strouhal number equal to 0.26. The effects of grazing flow on the impedance of Helmholtz resonators consisting of clusters of orifices was also studied. In general, both resistance and reaction were found to be virtually independent of orifice relative spacing and number. These findings are valid with and without grazing flow.

*Hersh Acoustical Engineering, contract NAS3-19745.

135 *Howlett, R. A.: **Advanced Supersonic Propulsion Study, Phase 4.** NASA CR-135273, 1977. (N78-11062)

Installation characteristics for a Variable Stream Control Engine (VSCE) were studied for three advanced supersonic airplane designs. Sensitivity of the VSCE concept to change in Technology projections was evaluated in terms of impact on overall installed performance. Based on these sensitivity results, critical technology requirements were reviewed, resulting in the reaffirmation of the following requirements: low-noise nozzle system, a high performance, low emissions duct burner and main burner; hot section technology variable geometry components; and propulsion integration features, including an integrated electronic control system.

*Pratt and Whitney Aircraft Group, contract NAS3-19540.

136 *Howlett, R. A.; and Hunt, R. B.: **VSCE Technology Definition Study — Final Report.** NASA CR-159730, [1977]. (N80-10222)

Refined design definition of the Variable Stream Control Engine (VSCE), an engine concept for advanced supersonic transports, has been accomplished in a NASA-sponsored, P&WA study contract. This design definition complements experimental programs that are being conducted for two of the unique and critical components that make up this engine: a high performance, low emissions duct burner for thrust augmentation and a high performance, low noise coannular nozzle system. The refined VSCE definition incorporates the latest results from these experimental programs, as well as updated design definition for all of the major engine components, with emphasis on the hot section of the engine core.

*Pratt and Whitney Aircraft Group, contract NAS3-21389.

137 *Jaeck, Carl L.: **Static and Wind Tunnel Near-Field/Far-Field Jet Noise Measurements From Model Scale Single-Flow Baseline and Suppressor Nozzles — Summary Report.** NASA CR-2841, 1977. (N77-26140)

A test program was conducted in the Boeing large anechoic test chamber and the NASA-Ames 40- by 80-foot wind tunnel to study the near- and far-field jet noise characteristics of six baseline and suppressor nozzles. Static and wind-on noise source locations were determined. A technique for extrapolating near field jet noise measurements into the far field was established. It was determined whether flight effects measured in the near field are the same as those in the far field. The flight effects on the jet noise levels of the baseline and suppressor nozzles were determined. Test models included a 15.24-cm round convergent nozzle, an annular nozzle with and without ejector, a 20-lobe nozzle with and without ejector, and a 57-tube nozzle with lined ejector. The static free-field test in the anechoic chamber covered nozzle pressure ratios from 1.44 to 2.25 and jet velocities from 412 to 594 m/s at a total temperature of 844 K. The wind tunnel flight effects test repeated these nozzle test conditions with ambient velocities of 0 to 92 m/s.

*Boeing Commercial Airplane Co., contract NAS2-8213.

138 *Knott, P. R.; Blozy, J. T.; and Staid, P. S.: **Acoustic and Aerodynamic Performance Investigation of Inverted Velocity Profile Coannular Plug Nozzles — Comprehensive Data Report.** NASA CR-159575, 1979.

Volume I.- Contains a description of the acoustic configurations, test facilities, data reduction techniques, test conditions, and detailed test results from the hot, static acoustic tests. (N79-26884)

Volume II.- Presents acoustic data comparisons in graphic form. (N79-26885)

Volume III.- Contains the detailed aerodynamic test results plus the concept screening and model design report. (N79-26886)

*General Electric Co., contract NAS3-19777.

139 *Knott, P. R.; Stringas, E. J.; Brausch, J. F.; Staid, P. S.; Heck, P. H.; and Latham, D.: **Acoustic Tests of Duct-Burning Turbofan Jet Noise Simulation.** NASA CR-2966, 1978. (N78-28043)

The selection procedure is described which was used to arrive at the configurations tested, and the performance characteristics of the test nozzles are given.

*General Electric Co., contract NAS3-18008.

140 *Kozlowski, H.; and Packman, A. B.: **Flight Effects on the Aerodynamic and Acoustic Characteristics of Inverted Profile Coannular Nozzles — Comprehensive Data Report.** NASA CR-135189, 1977.

Volume I.- Jet noise spectra obtained at static conditions from an acoustic wind tunnel and an outdoor facility are compared. Data curves are presented for (1) the effect of relative velocity on OASPL directivity (all configurations); (2) the effect of relative velocity on noise spectra (all configurations); (3) the effect of velocity on RNL directivity (coannular nozzle configurations); (4) nozzle exhaust plume velocity profiles; and (5) the effect of relative velocity on aerodynamic performance. (N78-29867)

Volume II.- Data from the acoustic tests of the convergent reference nozzle and the 0.75-area-ratio coannular nozzle are presented in tables. Data processing routines used to scale the acoustic data and to correct the data for atmospheric attenuation are included. (N78-29868)

Volume III.- Acoustic data from tests of the 0.75-area-ratio coannular nozzle with ejector and the

1.2-area-ratio coannular nozzle are presented in tables. Aerodynamic data acquired for the four test configurations are included. (N78-29869)

*Pratt and Whitney Aircraft Group, contract NAS3-17866.

141 *Kozlowski, Hilary; and Packman, Allan B.: **Aero-Acoustic Tests of Duct-Burning Turbofan Exhaust Nozzles — Comprehensive Data Report.** NASA CR-134910, 1977.

Volume I.- Model Scale Acoustic Data. (N78-15988)

Volume II.- Acoustic and Aerodynamic Data. (N78-15989)

Volume III.- Acoustic and Aerodynamic Data Curves. (N78-15990)

A compilation of all the detailed acoustic and aerodynamic data covering static aero-acoustic tests of duct-burning turbofan exhaust nozzles is presented. The basic model scale acoustic data and acoustic data scaled to full size is tabulated. In addition, perceived noise levels are shown at various sideline distances. A graphical presentation of the data is also given.

*Pratt and Whitney Aircraft Division, contract NAS3-17866.

142 *Kozlowski, Hilary; and Packman, Allan B.: **Flight Effects on the Aerodynamic and Acoustic Characteristics of Inverted Profile Coannular Nozzles.** NASA CR-3018, 1978. (N78-32836)

The effect of forward flight on the jet noise of coannular exhaust nozzles, suitable for Variable Stream Control Engines (VSCE), was investigated in a series of wind tunnel tests. The primary stream properties were maintained constant at 300 m/s and 394 K. A total of 230 acoustic data points were obtained. Force measurement tests using an unheated air supply covered the same range of tunnel speeds and nozzle pressure ratios on each of the nozzle configurations. A total of 80 points were taken. The coannular nozzle OASPL and PNL noise reductions observed statically relative to synthesized values were basically retained under simulated flight conditions. The effect of fan to primary stream area ratio on flight effects was minor. At take-off speed the peak jet noise for a VSCE was estimated to be over 6 PNdB lower than the static noise level. High static thrust coefficients were obtained for the basic coannular nozzles, with a decay of 0.75 percent at take-off speeds.

*Pratt and Whitney Aircraft Group, contract NAS3-17866.

143 *Larson, Richard S.; Nelson, Douglas P.; and Stevens, Bradley S.: **Aerodynamic and Acoustic Investigation of Inverted Velocity Profile Coannular Exhaust Nozzle Models and Development of Aerodynamic and Acoustic Prediction Procedures.** NASA CR-3168, 1979. (N79-31212)

Five coannular nozzle models, covering a systematic variation of nozzle geometry, were tested statically over a range of exhaust conditions including inverted velocity profile (IVP) (ratio of fan to primary stream velocity equal to 1) and non-IVP profiles. Fan nozzle pressure ratio (FNPR) was varied from 1.3 to 4.1 at primary nozzle pressure ratios (PNPR) of 1.53 and 2.0. Fan stream temperatures of 700 K (1260 R^{o}) and 1089 K (1960 R^{o}) were tested with primary stream temperatures of 700 K (1260 R^{o}), 811 K (1460 R^{o}), and 1089 K (1960 R^{o}). At fan and primary stream velocities of 610 and 427 m/sec (2000 and 1400 ft/sec), respectively, increasing fan radius ratio from 0.69 to 0.83 reduced peak perceived noise level (PNL) by 3 dB, and an increasing primary radius ratio from 0 to 0.81 (fan radius ratio constant at 0.83) reduced peak PNL by an additional 1.0 dB. There were no noise reductions at a fan stream velocity of 853 m/sec (2800 ft/sec). Increasing fan radius ratio from 0.69 to 0.83 reduced nozzle thrust coefficient by 1.2 to 1.5 percent at a PNPR of 1.53 and by 1.7 to 2.0 percent at a PNPR of 2.0. The developed acoustic prediction procedure collapsed the existing data with standard deviation varying from ±8 dB to ±7 dB. The aerodynamic performance prediction procedure collapsed thrust coefficient measurements to within ±0.004 at a PNPR of 4.0 and a PNPR of 2.0.

*Pratt and Whitney Aircraft Group, contract NAS3-20061.

144 *Larson, R. S.; Nelson, D. P.; and Stevens, B. S.: **Aerodynamic and Acoustic Investigation of Inverted Velocity Profile Coannular Exhaust Nozzle Models and Development of Aerodynamic and Acoustic Prediction Procedures — Comprehensive Data Report.** Volume I. NASA CR-159515, [1979]. (N79-30185)

The experimental data necessary to establish aerodynamic and acoustic prediction systems for coannular exhaust nozzles with inverted velocity profiles are presented in graphical form.

*Pratt and Whitney Aircraft Group, contract NAS3-20061.

145 *Larson, R. S.; Nelson, D. P.; and Stevens, B. S.: **Aerodynamic and Acoustic Investigation of Inverted Velocity Profile Coannular Exhaust Nozzle Models and Development of Aerodynamic and Acoustic Prediction Procedures — Comprehensive Data Report.** Volume II. NASA CR-159516, [1979]. (N79-30186)

The experimental data necessary to establish aerodynamic and acoustic prediction systems for coannular exhaust nozzles with inverted velocity profiles are presented in tabular form. The acoustic data are corrected to a 'theoretical day' and scaled to full engine size.

*Pratt and Whitney Aircraft Group, contract NAS3-20061.

146 *Lohmann, R. P.; and Mador, R. J.: **Experimental Evaluation of a Low Emissions High Performance Duct Burner for Variable Cycle Engines (VCE) — Final Report.** NASA CR-159694, [1979]. (N80-17074)

An evaluation was conducted with a three stage Vorbix duct burner to determine the performance and emission characteristics of the concept and to refine the configuration to provide acceptable durability and operational characteristics for its use in the variable cycle engine (VCE) testbed program. The tests were conducted at representative takeoff, transonic climb, and supersonic cruise inlet conditions for the VSCE-502B study engine. The test stand, the emissions sampling and analysis equipment, and the supporting flow visualization rigs are described. The performance parameters including the fuel-air ratio, the combustion efficiency/exit temperature, thrust efficiency, and gaseous emission calculations are defined. The test procedures are reviewed and the results are discussed.

*Pratt and Whitney Aircraft Group, contract NAS3-20602.

147 *Lohmann, R. P.; and Riecke, G. T.: **Analytical Screening of Low Emissions, High Performance Duct Burners for Supersonic Cruise Aircraft Engines.** NASA CR-135157, 1977. (N77-20102)

An analytical screening study was conducted to identify duct burner concepts capable of providing low emissions and high performance in advanced supersonic engines. Duct burner configurations ranging from current augmenter technology to advanced concepts such as premixed-prevaporized burners were defined. Aerothermal and mechanical design studies provided the basis for screening these configurations using the criteria of emissions, performance, engine compatibility, cost, weight, and relative risk. Technology levels derived from recently defined experimental low emissions main burners are required to achieve both low emissions and high performance goals. A configuration based on the Vorbix (vortex burning and mixing) combustor concept was analytically determined to meet the performance scale and is consistent with the fan duct envelope of a variable cycle engine. The duct burner configuration has a moderate risk level compatible with the schedule of anticipated experimental programs.

*Pratt and Whitney Aircraft, contract NAS2-19781.

148 *Lovell, W. A.: **ENGINEL: A Single Rotor Turbojet Engine Cycle Match Performance Program.** NASA CR-145267, 1977. (N78-12089)

ENGINEL is a computer program which was developed to generate the design and off-design performance of a single rotor turbojet engine with or without afterburning using a cycle match procedure. It is capable of producing engine performance over a wide range of altitudes and Mach numbers. The flexibility of operating with a variable geometry turbine for improved off-design fuel consumption or with a fixed geometry turbine as in conventional turbojets, has been incorporated. In addition, the option of generation engine performance with JP4, liquid hydrogen, or methane as fuel is provided.

*Vought Corp., contract NAS1-13500.

149 *McColgan, C. J.; and Larson, R. S.: **Mean Velocity, Turbulence Intensity and Turbulence Convection Velocity Measurements for a Convergent Nozzle in a Free Jet Wind Tunnel.** NASA CR-2949, 1978. (N78-21058)

The effects of light on the mean flow and turbulence properties of a 0.056 m circular jet were determined in a free jet wind tunnel. The nozzle exit velocity was 122 m/sec, and the wind tunnel velocity was set at 0, 12, 37, and 61 m/sec. Measurements of flow properties included mean velocity, turbulence intensity and spectra, and eddy convection velocity were carried out using two linearized hot wire anemometers. Normalization factors were determined for the mean velocity and turbulence convection velocity.

*Pratt and Whitney Aircraft Group, contract NAS3-17866.

150 *McColgan, C. J.; and Larson, R. S.: **Mean Velocity, Turbulence Intensity and Turbulence Convection Velocity Measurements for a Convergent Nozzle in a Free Jet Wind Tunnel — Comprehensive Data Report.** NASA CR-135238, 1977. (N78-17991)

The effect of flight on the mean flow and turbulence properties of a 0.056 m circular jet was determined in a free jet wind tunnel. The nozzle exit velocity was 122 m/sec, and the wind tunnel velocity was set at 9, 12, 37, and 61 m/sec. Measurements of flow properties including mean velocity, turbulence intensity and spectra, and eddy convection velocity were carried out using two linearized hot wire anemometers. This report contains the raw data and graphical presentations. The final technical report includes a description of the test facilities and test hardware, along with significant test results and conclusions.

*Pratt and Whitney Aircraft Group, contract NAS3-17866.

151 *Moore, M. T.; and Doyle, V. L.: **Evaluation of the In-Flight Noise Signature of a 32-Chute Suppressor Nozzle — Acoustic Data Report.** NASA CR-152076, 1977. (N78-19899)

Outdoor static and 40 × 80 ft wind tunnel tests of the J79-15 engine/nacelle system with the conic nozzle and 32-chute exhaust suppressor were conducted to acquire the data necessary to evaluate the simulated in-flight signature of an engine-size 32-chute exhaust nozzle suppressor using the 40 × 80 ft wind tunnel and to study possible engine core noise contamination of the jet signature. The tests are described and a sampling of the data acquired is presented. Included are aerodynamic performance summaries, as-measured and composite 1/3 OASPL spectra for the 70 ft sideline high and low microphones from the outdoor static tests, sideline traverse spectra and internal noise measurements from both the outdoor static and the 40 × 80 ft wind tunel tests.

*General Electric Co., contract NAS2-9312

152 *Nelson, D. P.; and Morris, P. M.: **Experimental Aerodynamic and Acoustic Model Testing of the VCE Coannular Exhaust Nozzle System.** NASA CR-159710, 1980.

Aerodynamic performance and jet noise characteristics of a one-sixth-scale model of the variable cycle engine (VCE) testbed exhaust system were obtained in a series of static tests over a range of simulated engine operating conditions. Model acoustic data were acquired that can be scaled directly to full-scale engine data at the same thermodynamic conditions. The model, tested with and without a hardwall ejector, had a total flow area equivalent to a 0.127-m (5-in.) diameter conical nozzle with a 0.65 fan to primary nozzle area ratio and a 0.82 fan nozzle radius ratio. Fan stream temperatures and velocities were varied from 422 to 1089 K (760^{o} R to 1960^{o} R) and 434 to 755 m/sec (1423 to 2477 ft/sec). Primary stream properties were varied from 589 to 1089 K (1060^{o} R to 1960^{o} R) and 353 to 600 m/sec (1158 to 1968 ft/sec). Exhaust plume velocity surveys were conducted at one operating condition with and without the ejector installed. Agreement between the acoustic test data and predictions without the ejector was generally within the accuracy of the prediction procedure. Acoustic data trends obtained by independently varying fan and primary stream properties were generally in agreement with the prediction procedure.

*Pratt and Whitney Aircraft Group, contract NAS3-20061.

153 *Pratt and Whitney Aircraft Group: **Technology Application Study of an Advanced Supersonic Cruise Vehicle.** Phase V — Advanced Supersonic Propulsion Studies. NASA CR-159315, 1977.

Pratt and Whitney Aircraft conducted a nine-month program for the McDonnell Douglas Corporation to study advanced-technology propulsion systems for a supersonic cruise aircraft conceptually defined by Douglas. This program is part of an overall effort to eventually establish a viable technology base for advanced supersonic aircraft systems. The scope of work consisted of conducting propulsion system analyses and engine/aircraft integration analyses with two engine concepts, a low bypass engine (LBE) and a variable stream control engine (VSCE). The main conclusion derived from this work is that both engine concepts are fully compatible with the Douglas supersonic cruise vehicle. The VSCE-511D study engine, with its unique variable throttle schedule, is the most promising engine concept on the basis of weight, overall performance and coannular noise benefits. The LBE-431 study engine is the preferred alternate engine definition.

*Douglas Aircraft Co., contract NAS1-14624.

154 *Pratt and Whitney Aircraft Group: **Technology Application Study of an Advanced Supersonic Cruise Vehicle.** Phase VI — Advanced Supersonic Propulsion Studies. NASA CR-159316, 1978.

Pratt and Whitney Aircraft (P&WA) has conducted a 10-month study program for the McDonnell Douglas Corporation (Douglas) to refine advanced technology propulsion systems for compatibility with a supersonic cruise aircraft concept defined by Douglas. This propulsion integration study program is part of an overall effort to establish an advanced technology base for future supersonic aircraft systems. The scope of the work consisted of conducting propulsion refinement analyses and engine/aircraft integration studies for two P&WA engine concepts, a variable stream control engine (VSCE) and low bypass engine (LBE). The main conclusion derived from this work is that both engine concepts are fully compatible with the advanced supersonic cruise vehicle defined by Douglas. The VSCE-511R study engine, with its unique variable throttle schedule and its adaptability to off-design mission requirements, is considered by P&WA to be the most promising engine concept on the basis of weight, overall performance and unsuppressed noise characteristics. The LBE-431R study engine, which incorporates a jet noise suppressor concept defined by Douglas, is considered to be an alternate engine concept.

*Douglas Aircraft Co., contract NAS1-14624.

155 *Pratt and Whitney Aircraft Group: **Technology Application Study of an Advanced Supersonic Cruise Vehicle.** Phase VII — Advanced Supersonic Propulsion and Studies. NASA CR-159323, 1980.

This report summarizes a contracted study of supersonic propulsion systems conducted for the McDonnell Douglas Corporation by Pratt and Whitney Aircraft. This study, referred to as Phase VII, was conducted during the period from March 1979 to December 1979. Phase VII was part of an overall Supersonic Cruise Research (SCR) study sponsored by NASA Langley Research Center under contract number NAS1-14624 and was a continuation of the integration studies performed by Pratt and Whitney Aircraft for McDonnell Douglas Corporation in Phase VI. The scope of work consisted of conducting propulsion refinement analyses for two Pratt and Whitney Aircraft engine concepts, a Variable Stream Control Engine (VSCE) and a Low Bypass Engine (LBE), establishment of a VSCE automated teleprocessing communications system, and a detailed performance assessment of the Pratt and Whitney Aircraft candidate nozzle exhaust systems for the LBE. The main conclusion derived from this work is that both engine concepts are fully compatible with the advanced supersonic cruise vehicle defined by Douglas.

*Pratt and Whitney Aircraft Group, contract NAS1-14624.

156 *Roberts, P. B.; and FioRito, R. J.: **Wide Range Operation of Advanced Low NO_x Combustors for Supersonic High-Altitude Aircraft Gas Turbines.** NASA CR-135297, 1977. (N78-14047)

An initial rig program tested the Jet Induced Circulation (JIC) and Vortex Air Blast (VAB) systems in small can combustor configurations for NO_x emissions at a simulated high altitude, supersonic cruise condition. The VAB combustor demonstrated the capability of meeting the NO_x goal of 1.0 g NO_2/kg fuel at the cruise condition. In addition, the program served to demonstrate the limited low emissions range available from the lean, premixed combustor. A follow-on effort was concerned with the problem of operating these lean, premixed combustors with acceptable emissions at simulated engine idle conditions. Various techniques have been demonstrated that allow satisfactory operation on both the JIB and VAB combustors at idle with CO emissions below 20 g/kg fuel. The VAB combustion was limited by flashback/autoignition phenomena at the cruise conditions to a pressure of

8 atmospheres. The JIC combustor was operated up to full design cruise pressure of 14 atmospheres without encountering an autoignition limitation although the NO_X levels, in the 2-3 g NO_2/kg fuel range, exceeded the program goal.

*Solar Turbines International, contract NAS3-19770.

157 *Shields, F. Douglas; and Bass, H. E.: **Atmospheric Absorption of High Frequency Noise and Application to Fractional-Octave Bands.** NASA CR-2760, 1977. (N77-28910)

Pure tone sound absorption coefficients were measured at 1/12 octave intervals from 4 to 100 kHz at 5.5 K temperature intervals between 255.4 and 310.9 K and at 10 percent relative humidity increments between 0 percent and saturation in a large cylindrical tube (i.e., 25.4 cm × 4.8 m). The results depended on spectrum shape, on filter type, and nonlinearly on propagation distance. For some of the cases considered, comparison with the extrapolation of ARP-866A showed a difference as large as a factor of 2. However, for many cases, the absorption for a finite band was nearly equal to the pure tone absorption at the center frequency of the band. A recommended prediction procedure is described for 1/3 octave band absorption coefficients.

*Mississippi University, contract NAS3-19431.

158 *Staid, Paul S.: **Wind Tunnel Performance Tests of Coannular Plug Nozzles.** NASA CR-2990, 1978. (N78-21044)

Wind tunnel performance test results and data analyses are presented for dual-flow plug nozzles applicable to supersonic cruise aircraft during takeoff and low-speed flight operation. Outer exhaust stream pressure ratios from 1.5 to 2.5 were tested; inner exhaust stream conditions were varied from very low, or bleed flow rates, up to a pressure ratio of 3.5. Mach numbers tested ranged from zero to 0.45. Measured thrust coefficients for the eight model configurations, operating at an external Mach number of 0.36 and an outer flow pressure ratio of 2.5, varied from 0.95 to 0.974 for high inner flow rates. At low inner flow, the performance ranged from 0.88 to 0.97 for the same operating conditions. The primary design variables influencing the performance levels were the annular height of the inner and outer nozzle throats (denoted by radius ratio, the ratio of inner to outer flowpath diameter at the nozzle throat), the plug geometry, and the inner stream flow rate.

*General Electric Co., contract NAS3-19777.

159 *Strout, Frank G.: **Flight Effects on Noise Generated by the JT8D Engine With Inverted Primary/Fan Flow as Measured in the NASA-Ames 40- by 80-Foot Wind Tunnel.** NASA CR-2996, 1978. (N78-26149)

A JT8D-17R engine with inverted primary and fan flows was tested under static conditions as well as in the NASA Ames 40- by 80-Foot Wind Tunnel to determine static and flight noise characteristics and flow profile of a large scale engine. Test and analysis techniques developed by a previous model and JT8D engine test program were used to determine the in-flight noise. The engine with inverted flow was tested with a conical nozzle and with a plug nozzle, 20 lobe nozzle, and an acoustic shield. Wind tunnel results show that forward velocity causes significant reduction in peak PNL suppression relative to uninverted flow. The loss of EPNL suppression is relatively modest. The in-flight peak PNL suppression of the inverter with conical nozzle was 2.5 PNdB relative to a static value of 5.5 PNdB. The corresponding EPNL suppression was 4.0 EPNdB for flight and 5.0 EPNdB for static operation. The highest in-flight EPNL suppression was 7.5 EPNdB obtained by the inverter with 20 lobe nozzle and acoustic shield. When compared with the JT8D engine with internal mixer, the inverted flow configuration provides more EPNL compression under both static and flight conditions.

*Boeing Commercial Airplane Co., contract NAS2-9302.

160 *Sullivan, T. J.; and Parker, D. E.: **Design Study and Performance Analysis of a High-Speed Multistage Variable-Geometry Fan for a Variable Cycle Engine.** NASA CR-159545, 1979. (N79-25020)

A design technology study was performed to identify a high speed, multi-stage, variable geometry fan configuration capable of achieving wide flow modulation with near optimum efficiency at the important operating condition. A parametric screening study of the front and rear block fans was conducted in which the influence of major fan design features on weight and efficiency was determined. Key design parameters were varied systematically to determine the fan configuration most suited for a double bypass, variable cycle engine. Two and three stage fans were considered for the front block. A single stage, core driven fan was studied for the rear block. Variable geometry concepts were evaluated to provide nearly optimum off-design performance. A detailed aerodynamic design and a preliminary mechanical design were carried out for the selected fan configuration. Performance predictions were made for the front and rear block fans.

*General Electric Co., contract NAS3-20041.

161 *Tyson, R. M.; Mairs, R. Y.; Halferty, F. D., Jr.; Moore, B. F.; Chaloff, D.; and Knudsen, A. W.: **Methods for Comparative Evaluation of Propulsion System Designs for Supersonic Aircraft.** NASA CR-135110, 1976. (N77-181156)

The propulsion system comparative evaluation study was conducted to define a rapid, approximate method for evaluating the effects of propulsion system changes for an advanced supersonic cruise airplane and to verify the approximate method by comparing its mission performance results with those from a more detailed analysis. A table lookup computer program was developed to determine nacelle drag increments for a range of parametric nacelle shapes and sizes. Aircraft sensitivities to propulsion parameters were defined. Nacelle shapes, installed weights, and installed performance were determined for four study engines selected from the NASA supersonic cruise aircraft research (SCAR) engine studies program. Both rapid evaluation method (using sensitivities) and traditional preliminary design methods were then used to assess the four engines. The method was found to compare well with the more detailed analyses.

*Rockwell International Corp., contract NAS3-19858. Omitted in previous bibliography.

162 *Vdoviak, John W.; and Thackeray, Michael J.: **Definition Study for a Variable Cycle Engine Testbed Engine and Associated Test Program.** NASA CR-159459, 1978. (N79-13048)

The product/study double bypass variable cycle engine (VCE) was updated to incorporate recent improvements. The effect of these improvements on mission range and noise levels was determined. This engine design was then compared with current existing high-technology core engines in order to define a subscale testbed configuration that simulated many of the critical technology features of the product/study VCE. Detailed preliminary program plans were then developed for the design, fabrication, and static test of the selected testbed engine configuration. These plans included estimated costs and schedules for the detail design, fabrication, and test of the testbed engine and the definition of a test program, test plan, schedule, instrumentation, and test stand requirements.

*General Electric Co., contract NAS3-20582A

163 *Westmoreland, J. S.; and Godston, J.: **VCE Testbed Program — Planning and Definition Study.** NASA CR-135362, 1978. (N78-19160)

The flight definition of the Variable Stream Control Engine (VSCE) was updated to reflect design improvements in the two key components: (1) the low emissions duct burner and (2) the coannular exhaust nozzle. The testbed design was defined and plans for the overall program were formulated. The effect of these improvements was evaluated for performance, emissions, noise, weight, and length. For experimental large scale testing of the duct burner and coannular nozzle, a design definition of the VCE testbed configuration was made. This included selecting the core engine, determining instrumentation requirements, and selecting the test facilities, in addition to defining control system and assembly requirements. Plans for a comprehensive test program to demonstrate the duct burner and nozzle technologies were formulated. The plans include both aeroacoustic and emission testing.

*Pratt and Whitney Aircraft Group, contract NAS3-20048.

164 *Westmoreland, J. S.; and Stern, A. M.: **Variable Cycle Engine Technology Program — Planning and Definition Study.** NASA CR-159539, [1978]. (N79-23084)

The variable stream control engine, VSCE-502B, was selected as the base engine, with the inverted flow engine concept selected as a backup. Critical component technologies were identified, and technology programs were formulated. Several engine configurations were defined on a preliminary basis to serve as demonstration vehicles for the various technologies. The different configurations present compromises in cost, technical risk, and technology return. Plans for possible variable cycle engine technology programs were formulated by synthesizing the technology requirements with the different demonstrator configurations.

*Pratt and Whitney Aircraft Group, contract NAS3-20811.

Articles, Meeting Papers, and Company Reports

165 Ahuja, K. K.; Tanna, H. K.; and Tester, B. J.: **Effects of Simulated Forward Flight on Jet Noise, Shock Noise and Internal Noise.** AIAA Paper 79-0615, Mar. 1979. (A79-26936)

166 Ahuja, K. K.; Tester, B. J.; Tanna, H. K.; and Searle, N.: **Experimental Study of Transmission, Reflection and Scattering of Sound in a Free-Jet Flight Simulation Facility and Comparison With Theory.** AIAA Paper 77-1266, Oct. 1977. (A77-51030)

167 Arndt, R. E. A.; Fuchs, H. V.; and Michel, U.: **Laboratory Study of Jet-Noise Suppressors.** J. Acoust. Soc. America, vol. 63, no. 4, Apr. 1978, pp. 1060-1068.

168 Bangert, L. H.; Burcham, F. W., Jr.; and Mackall, K. G.: **YF-12 Inlet Suppression of Compressor Noise: First Results.** AIAA Paper 80-0099, Jan. 1980. (A80-34537)

169 Bass, H. E.; and Shields, F. Douglas: **Absorption of Sound in Air: High-Frequency Measurements.** J. Acoust. Soc. America, vol. 62, no. 3, Sept. 1977, pp. 571-576.

170 Brown, R.: **Integration of a Variable Cycle Engine Concept in a Supersonic Cruise Aircraft.** AIAA Paper 78-1049, July 1978. (A78-43574)

171 Calder, P. H.; and Gupta, P. C.: **Engine Options for Supersonic Cruise Aircraft.** AIAA Paper 78-1054, July 1978. (A78-43576)

172 Cole, Gary L.; Dustin, Miles O.; and Neiner, George H.: **A Throat-Bypass Stability System Tested in a YF-12 Inlet.** J. Aircr., vol. 14, no. 1, Jan. 1977, pp. 15-22.

173 Evelyn, G. B.; Johnson, P. E.; and Sigalla, A.: **Propulsion for Future Supersonic Transports — 1978 Status.** AIAA Paper 78-1051, July 1978. (A78-48486)

174 Goodykoontz, Jack H.; and Stone, James R.: **Experimental Study of Coaxial Nozzle Exhaust Noise.** AIAA Paper 79-0631, Mar. 1979. (A79-28963)

175 Hines, R. W.: **Advanced Supersonic Transport Propulsion Requirements.** AIAA Paper 77-831, July 1977. (A77-41969)

176 Hines, Richard W.: **Variable Stream Control Engine for Supersonic Propulsion.** J. Aircr., vol. 15, no. 6, June 1978, pp. 321-325.

177 Howlett, R. A.; and Beattie, E. C.: **Integrated Control Systems for Advanced Supersonic Engines.** AIAA Paper 78-1050, July 1978. (A78-43575)

178 Howlett, Robert A.; and Smith, Martin G., Jr.: **Advanced Supersonic Transport Propulsion Systems.** SAE Paper 771010, Nov. 1977. (A78-23842)

179 Johnson, H. W.; and Conrad, E. W.: **NASA Engine System Technology Programs: An Overview.** AIAA Paper 78-928, July 1978. (A78-48452)

180 Jones, W. L.; and Groeneweg, J. F.: **State-of-the-Art of Turbofan Engine Noise Control.** NOISE-CON 77 Proceedings, George C. Maling, Jr., ed., Noise Control Found., c.1977, pp. 361-380. (In A78-35651)

181 Kauffman, C. W.; Subramaniam, A. K.; Rogers, D. W.; and Claus, R. W.: **The Effect of Ambient Conditions on the Emissions of an Idling Gas Turbine.** AIAA Paper 78-3, Jan. 1978. (A78-22551)

182 Krebs, J. N.; and Allan, R. D.: **Supersonic Propulsion — 1970 to 1977.** AIAA Paper 77-832, July 1977. (A77-41970)

183 Larson, R. S.: **A Jet Exhaust Noise Prediction Procedure for Inverted Velocity Profile Coannular Nozzles.** AIAA Paper 79-0633, Mar. 1979. (A79-28964)

184 Larson, R. S.: **Theoretical Jet Exhaust Model for the Duct Burning Turbofan.** AIAA Paper 77-1264, Oct. 1977. (A77-51028)

185 Larson, R. S.; McColgan, C. J.; and Packman, A. B.: **Jet Noise Source Modification Due to Forward Flight.** AIAA Paper 77-58, Jan. 1977. (A77-22215)

186 Packman, A. B.; Kozlowski, H.; and Gutierrez, O.: **Jet Noise Characteristics of Unsuppressed Duct Burning Turbofan Exhaust System.** J. Aircr., vol. 14, no. 3, Mar. 1977, pp. 227-232.

187 Packman, A. B.; and Ng, K. W.: **Effect of Simulated Forward Speed on the Jet Noise of Inverted Velocity Profile Coannular Nozzles.** AIAA Paper 77-1329, Oct. 1977. (A77-51083)

188 Payzer, Robert J.: **Variable Cycle Engine Applications and Constraints.** Variable Geomety and Multicycle Engines, AGARD-CP-205, Mar. 1977, pp. 13-1 – 13-13. (In N77-22112)

189 Radkey, R. L.; Welge, H. R.; and Roensch, R. L.: **Aerodynamic Design of a Mach 2.2 Supersonic Cruise Aircraft.** J. Aircr., vol. 15, no. 6, June 1978, pp. 351-357.

190 Rowe, W. T.; Johnson, E. S.; and McKinnon, R. A.: **Technology Status of Jet Noise Suppression Concepts for Advanced Supersonic Transports.** AIAA Paper 77-833, July 1977. (A77-41971)

191 Shields, F. Douglas; Bass, H. E.; and Bolen, L. N.: **Tube Method of Sound-Absorption Measurement Extended to Frequencies Far Above Cutoff.** J. Acoust. Soc. America, vol. 62, no. 2, Aug. 1977, pp. 346-353.

192 Stewart, W. L.; Weber, R. J.; and Johnson, H. W.: **A Review of NASA's Propulsion Programs for Civil Aviation.** AIAA Paper 78-43, Jan. 1978. (A78-20651)

193 Stone, James R.: **Prediction of In-Flight Exhaust Noise for Turbojet and Turbofan Engines.** Noise Control Eng., vol. 10, no. 1, Jan.-Feb. 1978, pp. 40-46.

194 Stone, James R.; Goodykoontz, Jack H.; and Gutierrez, Orlando A.: **Effects of Geometric and Flow-Field Variables on Inverted-Velocity-Profile Coaxial Jet Noise and Source Distributions.** AIAA Paper 79-0635, Mar. 1979. (A79-32126)

195 Tanna, H. K.; and Morris, P. J.: **In-Flight Simulation Experiments on Turbulent Jet Mixing Noise.** J. Sound & Vib., vol. 53, no. 3, Aug. 8, 1977, pp. 389-405.

196 Wasserbauer, Joseph F.; and Gerstenmaier, William H.: **Inlet-Engine Matching for SCAR Including Application of a Bicone Variable Geometry Inlet.** AIAA Paper 78-961, July 1978. (A78-45096)

197 Westmoreland, J. S.; Howlett, R. A.; and Lohmann, R. P.: **Progress on Variable Cycle Engines.** AIAA Paper 79-1312, June 1979. (A79-40759)

198 Willis, Edward: **Variable-Cycle Engines for Supersonic Cruise Aircraft.** Variable Geometry and Multicycle Engines, AGARD-CP-205, Mar. 1977, pp. 7-1 – 7-19. (In N77-22112)

199 Wilson, J. R.; and Benson, J. L.: **Propulsion System Airframe Integration Studies – Advanced Supersonic Transport.** AIAA Paper 78-1053, July 1978. (A78-48488)

SCR STRATOSPHERIC EMISSION IMPACT

NASA Formal Reports

200 Bittker, David A.; and Wong, Edgar L.: **Effect of Nitric Oxide on Photochemical Ozone Formation in Mixtures of Air With Molecular Chlorine and With Trichlorofluoromethane.** NASA TP-1192, 1978. (N78-20281)

Ozone formation in a reaction chamber at room temperature and atmospheric pressure was studied for the photolysis of mixtures of NO with either Cl_2 or $CFCl_3$ in air. Both Cl_2 + NO and $CFCl_3$ + NO in air strongly inhibited O_3 formation during the entire 2- to 4-hour reaction. A chemical mechanism that explains the results was presented. An important part of this mechanism was the formation and destruction of chlorine nitrate. Computations were performed with this same mechanism for $CFCl_3$-NO-air mixtures at stratospheric temperatures, pressures, and concentrations. Results showed large reductions in steady-state O_3 concentrations in these mixtures as compared with pure air.

201 Bittker, David A.; and Wong, Edgar L.: **Effect of Trichlorofluoromethane and Molecular Chlorine on Ozone Formation by Simulated Solar Radiation.** NASA TP-1093, 1977. (N78-12167)

Mixtures of air with either Cl_2 or $CFCl_3$ were photolyzed in a reaction chamber by simulated solar radiation. Ozone formation was temporarily inhibited by Cl_2 and permanently inhibited by $CFCl_3$. A chemical mechanism including gas phase and wall reactions is proposed to explain these results. The $CFCl_3$ is assumed to be adsorbed on the chamber walls and to poison the sites for Cl destruction.

202 Diehl, Larry A.; Reck, Gregory M.; Marek, Cecil J.; and Szaniszlo, Andrew J.: **Stratospheric Cruise Emission Reduction Program.** Aircraft Engine Emissions, NASA CP-2021, 1977, pp. 357-391. (In N78-11063)

This paper discusses the stratospheric cruise emission reduction program (SCERP), which is specifically aimed at reducing cruise oxides of nitrogen from high-altitude aircraft. First, the desired emission levels and the combustor technology that will be required to achieve them are discussed. Second, a brief overview of the SCERP operating plan is given. Next, lean premixed-prevaporized combustion and some of the potential difficulties that are associated with applying this technique to gas turbine combustors are examined. The first program phase of SCERP is then discussed in more detail. The objective of this first phase is to develop base technology in several key areas. These fundamental studies are viewed as a requirement for successful implementation of the lean premixed combustion technique.

203 Poppoff, I. G.; Whitten, R. C.; Turco, R. P.; and Capone, L. A.: **An Assessment of the Effect of Supersonic Aircraft Operations on the Stratospheric Ozone Content.** NASA RP-1026, 1978. (N78-30774)

An assessment of the potential effect on stratospheric ozone of advanced supersonic transport operations is presented. This assessment, which was undertaken because of NASA's desire for an up-to-date evaluation to guide programs for the development of supersonic technology and improved aircraft engine designs, uses the most recent chemical reaction rate data. From the results of the present assessment, it would appear that realistic fleet sizes should not cause concern with regard to the depletion of the total ozone overburden. For example, the NO_X emission of one type designed to cruise at 20 km altitude will cause the ozone overburden to increase by 0.03 percent to 0.12 percent, depending upon which vertical transport is used. These ozone changes can be compared with the predictions of a 1.74 percent ozone decrease (for 100 large SST's flying at 20 km) made in 1974 by the FAA's Climatic Impact Assessment Program.

NASA Contractor Reports

204 *Von Thüna, Peter C.: **Design of an Airborne Laser Spectrometer.** NASA CR-145131, [1977]. (X77-10086)

A detailed investigation of the engineering implications and the expected performance margins of an infrared laser diode spectrometer system is described. An overall systems design and optical schematic are included and crucial optical problems are identified.

*Arthur D. Little, Inc., contract NAS1-14027.

Articles, Meeting Papers, and Company Reports

205 Brockman, P.; Bair, C. H.; and Allaris, F.: **High Resolution Spectral Measurement of the HNO_3 11.3-μm Band Using Tunable Diode Lasers.** Appl. Opt., vol. 17, no. 1, Jan. 1, 1978, pp. 91-100.

206 Farmer, C. B.; and Raper, O. F.: **The HF:HCl Ratio in the 14-38 km Region of the Stratosphere.** Geophys. Res. Lett., vol. 4, no. 11, Nov. 1977, pp. 527-529.

207 Matloff, Gregory L.; and Hoffert, Martin I.: **A Computationally Fast One-Dimensional Diffusion-Photochemistry Model of SST Wakes.** AIAA J., vol. 15, no. 8, Aug. 1977, pp. 1205-1207.

208 Oliver, R. C.; Bauer, E.; Hidalgo, H.; Gardner, K. A.; and Wasylkiwskyj, W.: **Aircraft Emissions: Potential Effects on Ozone and Climate – A Review.** FAA-EQ-77-3, Mar. 1977. (N78-16489)

Available from DTIC as AD A040 638.

209 Raper, O. F.; Farmer, C. B.; Toth, R. A.; Robbins, B. D.: **The Vertical Distribution of HCl in the Stratosphere.** Geophys. Res. Lett., vol. 4, no. 11, Nov. 1977, pp. 531-534.

210 Rogowski, R. S.; Bair, C. H.; Wade, W. R.; Hoell, J. M.; and Copeland, G. E.: **Infrared Vibration-Rotation Spectra of the ClO Radical Using Tunable Diode Laser Spectroscopy.** Appl. Opt., vol. 17, no. 9, May 1, 1978, pp. 1301-1302.

211 Turco, R. P.; Toon, O. B.; Pollack, J. B.; Whitten, R. C.; Poppoff, I. G.; and Hamill, P.: **Stratospheric Aerosol Modification by Supersonic Transport and Space Shuttle Operations – Climate Implications.** J. Appl. Meteorol., vol. 19, no. 1, Jan. 1980, pp. 78-89.

SCR STRUCTURES & MATERIAL

NASA Formal Reports

212 Abel, Irving: **An Analytical Technique for Predicting the Characteristics of a Flexible Wing Equipped With an Active Flutter-Suppression System and Comparison With Wind-Tunnel Data.** NASA TP-1367, 1979. (N79-17264)

An analytical technique for predicting the performance of an active flutter-suppression system is presented. This technique is based on the use of an interpolating function to approximate the unsteady aerodynamics. The resulting equations are formulated in terms of linear, ordinary differential equations with constant coefficients. This technique is then applied to an aeroelastic model wing equipped with an active flutter-suppression system. Comparisons between wind-tunnel data and analysis are presented for the wing both with and without active flutter suppression. Results indicate that the wing flutter characteristics without flutter suppression can be predicted very well but that a more adequate model of wind-tunnel turbulence is required when the active flutter-suppression system is used.

213 Bales, Thomas T.; Wiant, H. Ross; and Royster, Dick M.: **Brazed Borsic/Aluminum Structural Panels.** NASA TM X-3432, 1977. (N77-18220)

A fluxless brazing process has been developed that minimizes degradation of the mechanical properties of Borsic/aluminum composites. The process, which employs 718 aluminum alloy braze, is being used to fabricate full-scale Borsic/aluminum titanium honeycomb core panels for Mach 3 flight testing on the YF-12 aircraft and ground testing in support of the Supersonic Cruise Aircraft Research (SCAR) Program. The manufacturing development and results of shear tests on full-scale panels are presented.

214 Bennett, Robert M.; and Bland, Samuel R.: **Some Calculations of Transonic Potential Flow for the NACA 64A006 Airfoil With an Oscillating Flap.** Advanced Technology Airfoil Research – Volume I, NASA CP-2045, Pt. 2, 1979, pp. 689-700. (In N79-19989)

A method for calculating the transonic flow over steady and oscillating airfoils was developed by Isogai. It solves the full potential equation with a semi-implicit, time-marching, finite difference technique. Steady flow solutions are obtained from time asymptotic solutions for a steady airfoil. Corresponding oscillatory solutions are obtained by initiating an oscillation and marching in time for several cycles until a converged periodic solution is achieved. In this paper the method is described in general terms, and results are compared with experimental data for both steady flow and for oscillations at several values of reduced frequency. Good agreement for static pressures is shown for subcritical speeds, with increasing deviation as Mach number is increased into the supercritical speed range. Fair agreement with experiment was obtained at high reduced frequencies with larger deviations at low reduced frequencies.

215 Carden, Huey D.; and McGehee, John R.: **Improvements to the FATOLA Computer Program Including Nosewheel Steering – Supplemental Instruction Manual.** NASA TM-78768, 1978. (N79-14081)

Modifications to a multi-degree-of-freedom flexible aircraft take-off and landing analysis (FATOLA) computer program, which improved its simulation capabilities, are discussed, and supplemental instructions for use of the program are included. Sample analytical results which illustrate the capabilities of an added nosewheel steering option indicate consistent behavior of the airplane tracking, attitude, motions, and loads for the landing bases and steering situations which were investigated.

216 Carden, Huey D.; and McGehee, John R.: **Validation of a Flexible Aircraft Take-Off and Landing Analysis (FATOLA).** NASA TP-1025, 1977. (N78-10049)

Modifications to improve the analytical simulation capabilities of a multi-degree-of-freedom flexible aircraft take-off and landing analysis (FATOLA) computer program are discussed. The FATOLA program was used to simulate the landing behavior of a stiff body X-24B reentry research vehicle and of a flexible body supersonic cruise YF-12A research airplane. The analytical results were compared with flight test data and correlations of vehicle motions, attitudes, forces, and accelerations during the landing impact and rollout were good. For the YF-12A airplane, airframe flexibility was found to be important for nose gear loading. Based upon the correlation study presented, the versatility and validity of the FATOLA program for the study of landing dynamics of aircraft are confirmed.

217 *Davis, Richard E.; Champine, Robert A.; and Ehernberger, L. J.: **Meteorological and Operation Aspects of 46 Clear Air Turbulence Sampling Missions With an Instrumented B-57B Aircraft.** Volume I – Program Summary. NASA TM-80044, 1979. (N79-25667)

The results of 46 clean air turbulence (CAT) probing missions conducted with an extensively instrumented B-57B aircraft are summarized. Turbulence samples were obtained under diverse conditions including mountain waves, jet streams, upper level fronts and troughs, and low altitude mechanical and thermal turbulence. CAT was encouraged on 20 flights comprising 77 data runs. In all, approximately 4335 km were flown in light turbulence, 1415 km in moderate turbulence, and 255 km in severe turbulence during the program. The flight planning, operations, and turbulence forecasting aspects conducted with the B-57B aircraft are presented.

*Volume II (Appendix C) by D. E. Waco is entry 250.

218 Ehernberger, L. J.: **The YF-12 Gust Velocity Measuring System.** YF-12 Experiments Symposium – Volume 1, NASA CP-2054, 1978, pp. 135-154. (In N78-32055)

A true gust velocity measuring system designed to alleviate complications resulting from airframe flexibility and from the high-speed, high-temperature environment of supersonic cruise aircraft was evaluated on a YF-12 airplane. A unique feature of the system is the use of fixed vanes on which airflow direction changes produce differential pressure variations that are measured. Airframe motions are removed from the flow angle data. An example of turbulence data obtained at high-altitude, supersonic flight conditions is presented. Results of these comparisons indicate that the YF-12 turbulence sample is representative of turbulence present in the supersonic cruise environment.

219 Fischler, J. E.: **Opportunities for Structural Improvements for an Advanced Supersonic Transport Vehicle.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 589-616. (In X80-72367)

The superplastically formed diffusion-bonded (SPF/DB) program has developed far enough to recommend that a major structural program to validate the weight and cost of SPF/DB sandwich titanium structure should be initiated. The NASA Langley study of wing and fuselage SPF/DB sandwich panels helped to show that this process is potentially structurally efficient. The Douglas SPF/DB expanded sandwich process that utilizes a welded core sheet that expands to face sheets has proven to be very efficient. Douglas has successfully fabricated many rectangular, triangular, and isogrid core sandwich structures by this process. The theoretical weight optimization design charts for the wing and fuselage concepts have been validated by small-scale tests. Many design applications have been fabricated. Projecting the results of an SPF/DB sandwich airframe structure to a MDC AST design shows significant weight and cost savings. A 6-percent lower direct operating cost (DOC) has been calculated. A growth AST utilizing composites, metal matrices, and SPF/DB sandwich shows future promise for a post-1990 technology readiness. Titanium SPF/DB sandwich has been compared to presently available aluminum structure and found to be superior for application to a Mach 2.2 supersonic transport.

220 Greene, W. H.; and Sobieszczanski-Sobieski, J.: **Minimum Mass Sizing of a Large Low-Aspect Ratio Airframe for Flutter-Free Performance.** NASA TM-81818, 1980. (N80-23683)

A procedure for sizing an airframe for flutter-free performance is demonstrated on a large, flexible supersonic transport aircraft. The procedure is based on using a two level reduced basis or modal technique for reducing the computational cost of performing the repetitive flutter analyses. The supersonic transport aircraft exhibits complex dynamic behavior, has a well-known flutter problem and requires a large finite element model to predict the vibratory and flutter response. Flutter-free designs were produced with small mass increases relative to the wing structural weight and aircraft payload.

221 Guess, Marlon K.; Kaneko, Russell S.; and Wald, George G.: **Advanced Materials and Fabrication Processes for Supersonic Cruise Aircraft.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 687-712. (In X80-72367)

Research and development programs to develop high-strength aluminum alloys and low-cost materials and fabrication techniques for titanium alloys are being conducted by the Lockheed-California Company under contract to NASA Langley Research Center and through independent research. Thirteen aluminum alloy compositions are being evaluated by Aluminum Company of America (Alcoa) and the International Nickel Company (INCO) under subcontract to Lockheed. A section of a production component has been fabricated using superplastic forming and diffusion bonding (SPF/DB) and fabrication studies are being conducted on three low-temperature-forming beta titanium alloys. Cost studies indicate substantial structural cost-reduction potentials resulting from the use of both aluminum alloys and low-cost titanium fabrication techniques. Lowest overall costs are indicated for a composite/aluminum or composite titanium structure.

222 Hardrath, H. F.; Newman, J. C., Jr.; Elber, W.; and Poe, C. C., Jr.: **Recent Developments in Analysis of Crack Propagation and Fracture of Practical Materials.** NASA TM-78766, 1978. (N78-30606)

The limitations of linear elastic fracture mechanics in aircraft design and in the study of fatigue crack propagation in aircraft structures are discussed. NASA Langley research to extend the capabilities of fracture mechanics to predict the maximum load that can be carried by a cracked part and to deal with aircraft design problems is reported. Achievements include (1) improved stress intensity solutions for laboratory specimens, (2) fracture criterion for practical materials, (3) crack propagation predictions that account for mean stress and high maximum stress effects, (4) crack propagation predictions for variable amplitude loading, and (5) the prediction of crack growth and residual stress in built-up structural assemblies. These capabilities are incorporated into a first generation computerized analysis that allows for damage tolerance and tradeoffs with other disciplines to produce efficient designs that meet current airworthiness requirements.

223 Hendricks, Carl L.; and Hill, Sylvester G.: **Evaluation of High-Temperature Structural Adhesives for Extended Service.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 675-686. (In X80-72367)

Candidate high-temperature stable resin formulations were evaluated for adhesive properties when bonded to titanium treated with various surface preparations. The adhesive formulations included LARC-13, NR150 A2, NR150 B2, NR056X, FM-34, HR-602, and polyphenylquinoxaline. Eight titanium surface preparations were compared for resulting bond strength with the candidate adhesives. After initial evaluation, three adhesive systems (comprised of adhesive, primer, and titanium surface preparation) were selected for further screening. The screening included cure-cycle optimization and bond properties from 219 K (-65° F) to 505 K (450° F), after isothermal aging at 505 K (450° F) up to 15 000 hours, and after humidity aging at 322 K (120° F) and 95 percent R. H. for up to 2000 hours. Large-area bond capability of the three adhesive systems will be demonstrated by fabrication of 30.5-cm (12-in.) square titanium honeycomb sandwich and metal-to-metal bonded panels.

224 Isogai, Koji: **Numerical Study of Transonic Flow Over Oscillating Airfoils Using the Full Potential Equation.** NASA TP-1120, 1978. (N78-21055)

The behavior of unsteady aerodynamic loadings on airfoils oscillating in transonic flow has been investigated numerically with particular attention given to supercritical airfoil sections. A previously developed finite difference method, which is based on the full potential equation and which uses a quasi-conservative scheme for proper capture of a shock wave motion, was employed for the present study. The unsteady aerodynamic pressure and load distributions on several different airfoil sections are presented with particular emphasis on the effects of free-stream Mach number, reduced frequency, and mean angle of attack. These parameters are demonstrated to have a significant effect on the behavior of the unsteady aerodynamic loadings. Comparisons of the present calculations with the exact inviscid solution and with the experimental results are also presented.

225 Jenkins, Jerald M.; and Kuhl, Albert E.: **Recent Load Calibrations Experience With the YF-12 Airplane.** YF-12 Experiments Symposium – Volume 1, NASA CP-2054, 1978, pp. 47-72. (In N78-32055)

The use of calibrated strain gages to measure wing loads on the YF-12A airplane is discussed as well as structural configurations relative to the thermal environment and resulting thermal stresses. A thermal calibration of the YF-12A is described to illustrate how contaminating thermal effects can be removed from load equations. The relationship between ground load calibrations and flight measurements is examined for possible errors, and an analytical approach to accommodate such errors is presented.

226 McWithey, Robert R.; Royster, Dick M.; and Ko, William L.: **Compression Panel Studies for Supersonic Cruise Vehicles.** NASA TP-1617, 1980. (X80-10055)

Results of analytical and experimental studies are summarized for titanium, boron-fiber-reinforced aluminum-matrix composite, Borsic®-fiber-reinforced aluminum-matrix composite, and titanium-sheathed Borsic-fiber-reinforced aluminum-matrix composite stiffened panels. The results indicate that stiffened panels with continuous joints (i.e., brazed, diffusion-bonded, or adhesive-bonded joints) are more structurally efficient than geometrically similar panels with discrete joints (i.e., spotwelded or bolted joints). In addition, results for various types of fiber-reinforced aluminum-matrix stiffened panels indicate that titanium-sheathed Borsic-fiber-reinforced aluminum-matrix composite panels are the most structurally efficient. Analytical results are also presented for graphite-fiber-reinforced polyimide-matrix composite stiffened panels and superplastically formed and diffusion-bonded titanium sandwich panels.

227 Meyer, Robert R., Jr.; and DeAngelis, V. Michael: **Flight-Measured Aerodynamic Loads on a 0.92 Aspect Ratio Lifting Surface.** YF-12 Experiments Symposium – Volume 1, NASA CP-2054, 1978, pp. 73-91. (In N78-32055)

Ventral fin loads were measured during flight tests of a YF-12A airplane. The aerodynamic loads presented were the result of both sideslip loads and aileron cross-flow loads. Aerodynamic data obtained from strain gage loads instrumentation and some flight pressure measurements are presented for several Mach numbers ranging from 0.70 to 2.00. Selected wind tunnel data and results of linear theoretical aerodynamic calculations are presented for comparison.

228 Newman, J. C., Jr.: **A Review and Assessment of the Stress-Intensity Factors for Surface Cracks.** NASA TM-78805, 1978. (N79-15327)

The stress-intensity factor solutions proposed for a surface crack in a finite plate subjected to uniform tension are reviewed. Fourteen different solutions for the stress intensity factors are compared. These solutions were obtained over the past 16 years using approximate analytical methods, experimental methods, and engineering estimates. The accuracy is assessed of the various solutions by correlating fracture data on surface-cracked tension specimens made of a brittle epoxy material. Fracture of the epoxy material was characterized by a constant value of stress-intensity factor at failure. Thus, the correctness of the various solutions is judged by the variations in the stress-intensity factors at failure. The solutions were ranked in order of minimum standard deviation. The highest ranking solutions correlated 95 percent of data analyzed within ±10 percent, whereas the lowest ranking solutions correlated 95 percent of data analyzed within ±20 percent. However, some solutions could be applied to all data considered, whereas others were limited with respect to crack shapes and crack sizes that could be analyzed.

229 Nissim, E.; and Abel, I.: **Development and Application of an Optimization Procedure for Flutter Suppression Using the Aerodynamic Energy Concept.** NASA TP-1137, 1978. (N78-18459)

An optimization procedure is developed based on the responses of a system to continuous gust inputs. The procedure uses control law transfer functions which have been partially determined by using the relaxed aerodynamic energy approach. The optimization on procedure yields a flutter suppression system which minimizes control surface activity in a gust environment. The procedure is applied to wing flutter of a drone aircraft to demonstrate a 44 percent increase in the basic wing flutter dynamic pressure. It is shown that a trailing edge control system suppresses the flutter instability over a wide range of subsonic Mach numbers and flight altitudes. Results of this study confirm the effectiveness of the relaxed energy approach.

230 Poe, C. C., Jr.; and Kennedy, John M.: **An Assessment of Buffer Strips for Improving Damage Tolerance of Composite Laminates.** Supersonic Cruise Research '79 – Part 2, NASA CP-2108, 1980, pp. 657-673. (In X80-72367)

Graphite/epoxy panels with buffer strips were tested in tension to measure their residual strength with crack-like damage. Panels were made with $[45/0\text{-}45/90]_{2S}$ and $[45/0\text{-}45/0]_{2S}$ layups. The buffer strips were parallel to the loading directions. They were made by replacing narrow strips of the 0° graphite plies with strips of either 0° S-Glass/epoxy or Kevlar-49/epoxy on either a one-for-one or a two-for-one basis. In a third case, 0° graphite/epoxy was used as the buffer material and thin, perforated Mylar strips were placed between the 0° plies and the cross-plies to weaken the interfaces and thus to isolate the 0° plies. Some panels were made with buffer strips of different widths and spacings. The buffer strips arrested the cracks and increased the residual strengths significantly over those of plain laminates without buffer strips. A shear-lag-type stress analysis correctly predicted the effects of layup, buffer material, buffer strip width and spacing, and the number of plies of buffer material.

231 Pride, Richard A.: **Environmental Effects on Composites for Aircraft.** CTOL Transport Technology – 1978, NASA CP-2036, Pt. I, 1978, pp. 239-258. (In N78-27046)

The influence of the operational environment on the behavior of composite materials and aircraft components fabricated with these composite materials was considered. Structural weight savings, manufacturing cost savings, and long-term environmental durability are among the factors examined. The flight service experience to date of composite components is evaluated. In addition, the influence of a number of worldwide, ground based outdoor exposures on the physical and mechanical properties of six composite materials is discussed. In particular, the current extent of the ultraviolet surface degradation and the moisture gained by diffusion is shown.

232 Raju, I. S.; and Newman, J. C., Jr.: **Stress-Intensity Factors for Corner Cracks at the Edge of a Hole.** NASA TM-78728, 1978. (N78-26491)

This paper presents stress-intensity factors, calculated by a three-dimensional finite-element analysis, for shallow or deep quarter-elliptical corner cracks at the edge of a hole in a finite-thickness plate. The plate was subjected to remote uniform tension, remote bending, or simulated pin loading in the hole. The ratio of crack depth to plate thickness ranged from 0.2 to 0.8, while the ratio of crack depth to crack length ranged from 0.2 to 2. The ratio of hole radius to plate thickness was held at 0.5. The stress-intensity factor variations along the crack front are presented and compared with other solutions from the literature.

233 Rhodes, Marvin D.: **Impact Tests on Fibrous Composite Sandwich Structures.** NASA TM-78719, 1978. (N78-33152)

The effect of low velocity impact on the strength of laminates fabricated from graphite/epoxy and Kevlar 49 epoxy composite materials was studied. The test laminates were loaded statically either in uniaxial tension or compression when impact occurred to evaluate the effect of loading on the initiation of damage and/or failure. Typical aircraft service conditions such as runway debris encountered during landing were simulated by impacting 1.27-cm-diameter projectiles normal to the plane of the test laminates at velocities between 5.2 and 48.8 m/s.

234 Royster, Dick M.; McWithey, Robert R.; and Bales, Thomas T.: **Fabrication and Evaluation of Brazed Titanium-Clad Borsic®/Aluminum Compression Panels.** NASA TP-1573, 1980. (X80-10043)

Processes for brazing Borsic/aluminum composite materials that eliminate diffusion of braze alloy constituents into the aluminum matrix have been developed at the NASA Langley Research Center. One brazing study led to the development of a hybrid composite which combines high strength Borsic/aluminum and ductile titanium to form a material identified as titanium-clad Borsic/aluminum. The titanium foil provides the Borsic/aluminum with a durable outer surface and serves as a diffusion barrier which alleviates fiber and matrix degradation during brazing. Titanium-clad Borsic/aluminum skin panels were joined to titanium-clad Borsic/aluminum stringers by brazing and were tested in end compression at room and elevated temperatures. The data include failure strength, buckling strength, and the effects of brazing on the material properties. Predicted buckling loads are compared with experimental data.

235 Royster, Dick M.; Wiant, H. Ross; and McWithey, Robert R.: **Effects of Fabrication and Joining Processes on Compressive Strength of Boron/Aluminum and Borsic/Aluminum Structural Panels.** NASA TP-1121, 1978. (N78-20256)

Processes for forming and joining boron/aluminum and borsic/aluminum to themselves and to titanium alloys were studied. Composite skin and titanium skin panels were joined to composite stringers by high strength bolts, by spotwelding, by diffusion bonding, by adhesive bonding, or by brazing. The effects of the fabrication and joining processes on panel compressive strengths were discussed. Predicted buckling loads were compared with experimental data.

236 St. Clair, Terry L.; and Jewell, Robert A.: **Solventless LARC-160 Polyimide Matrix Resin.** NASA TM-74994, 1978. (N78-16187)

The addition polymide, LARC-160, which was originally synthesized from low cost liquid monomers as a laminating resin in ethanol, was prepared as a solventless, high viscosity, neat liquid resin. The resin was processed by hot-melt coating techniques into graphite prepreg with excellent tack and drape. Comparable data on graphite reinforced laminates made from solvent-coated and various hot-melt coated prepreg were generated. LARC-160, because of its liquid nature, can be easily autoclave processed to produce low void laminates. Liquid chromatographic fingerprints indicate good reaction control on resin scale-ups. Minor changes in monomer ratios were also made to improve the thermal aging performance of graphite laminates.

237 Sakata, I. F.; Davis, G. W.; and Saelman, B.: **Structural Concept Trends for Commercial Supersonic Cruise Aircraft Design.** Supersonic Cruise Research '79 — Part 2, NASA CP-2108, 1980, pp. 563-587. (In X80-72367)

An analytical study was performed to establish structural concept trends for future commercial supersonic transport aircraft. Highlights of an earlier contractual study and of a recent Lockheed independent development study are discussed. Knowledge of these design parameters, as determined through studies involving the application of flexible mathematical models, enabled inclusion of aeroelastic considerations in the structural-material concept evaluation. The design trends and weight data of the previous contractual study of a Mach 2.7 cruise aircraft were used as the basis for incorporating advanced materials and manufacturing approaches to the airframe for reduced weight and cost. Structural studies of design concepts employing advanced aluminum alloys, advanced composites, and advanced titanium alloy and manufacturing techniques are compared for a Mach 2.0 arrow-wing configuration concept. Appraisals of the impact of these new materials and manufacturing concepts to the airframe design are shown and compared.

238 Sidwell, Kenneth: **Analysis of Dynamic System Response to Product Random Processes.** NASA TM-78667, 1978. (N78-32798)

The response of dynamic systems to the product of two independent Gaussian random processes is developed by use of the Fokker Planck and associated moment equations. The development is applied to the amplitude modulated process which is used to model atmospheric turbulence in aeronautical applications. The exact solution for the system response is compared with the solution obtained by the quasi-steady approximation which omits the dynamic properties of the random amplitude modulation. The quasi-steady approximation is valid as a limiting case of the exact solution for the dynamic response of linear systems to amplitude modulated processes. In the nonlimiting case the quasi-steady approximation can be invalid for dynamic systems with low damping.

239 Sobieszczanski-Sobieski, J.; Gross, David; Kurtze, William; Newsom, Jerry; Wrenn, Gregory; and Greene, William: **Supersonic Cruise Research Aircraft Structural Studies: Methods and Results.**

Supersonic Cruise Research '79 — Part 2, NASA CP-2108, 1980, pp. 617-656. (In X80-72367)

This paper reviews NASA Langley Research Center SCAR in-house structural studies that have been accomplished since the SCAR conference in November 1976. Both method development and results generated are covered. In method development, advances include a new system of integrated computer programs called ISSYS, progress in determining aerodynamic loads and aerodynamically induced structural loads (including those due to gusts), flutter optimization for composite and metal airframe configurations using refined and simplified mathematical models, and synthesis of active controls. Results given address several aspects of various SCAR configurations. These results include flutter penalties on a composite wing, flutter suppression using active controls, roll control effectiveness, wing tip ground clearance, tail size effect on flutter, engine weight and mass distribution influence on flutter, and strength and flutter optimization of new configurations. The ISSYS system of integrated programs performed well in all the applications illustrated by the results, the diversity of which attests to ISSYS's versatility.

240 Sobieszczanski-Sobieski, Jaroslaw: **An Integrated Computer Procedure for Sizing Composite Airframe Structures.** NASA TP-1300, 1979. (N79-17580)

A computerized algorithm to generate cross-sectional dimensions and fiber orientations for composite airframe structures is described, and its application in a wing structural synthesis is established. The algorithm unifies computations of aeroelastic loads, stresses, and deflections, as well as optimal structural sizing and fiber orientations in an open-ended system of integrated computer programs. A finite-element analysis and a mathematical-optimization technique are discussed.

241 Sobieszczanski-Sobieski, Jaroslaw; and Goetz, Robert C.: **Synthesis of Aircraft Structures Using Integrated Design and Analysis Methods — Status Report.** Research in Computerized Structural Analysis and Synthesis, Harvey G. McComb, Jr., compiler, NASA CP-2059, 1978, pp. 63-76. (In N79-10448)

This paper gives a status report and describes the work directions of a systematic research effort to develop and validate methods for structural sizing of an airframe designed with the use of composite materials and active controls. This research program includes procedures for computing aeroelastic loads, static and dynamic aeroelasticity, analysis and synthesis of active controls, and optimization techniques. Development of the methods is concerned with the most effective ways of integrating and sequencing the procedures in order to generate structural sizing and the associated active control system, which is optimal with respect to a given merit function constrained by strength and aeroelasticity requirements.

242 Sova, J. A.; and Poe, C. C., Jr.: **Tensile Stress-Strain Behavior of Boron/Aluminum Laminates.** NASA TP-1117, 1978. (N78-18135)

The tensile stress-strain behavior of five types of boron/aluminum laminates was investigated. Longitudinal and transverse stress-strain curves were obtained for monotonic loading to failure and for three cycles of loading to successively higher load levels. The laminate strengths predicted by assuming that the zero degree plies failed first correlated well with the experimental results. The stress-strain curves for all the boron/aluminum laminates were nonlinear except at very small strains. Within the small linear regions, elastic constants calculated from laminate theory corresponded to those obtained experimentally to within 10 to 20 percent. A limited amount of cyclic loading did not affect the ultimate strength and strain for the boron/aluminum laminates. The laminates, however, exhibited a permanent strain on unloading. The Ramberg-Osgood equation was fitted to the stress-strain curves to obtain average curves for the various laminates.

243 Staff, Langley Research Center: **Concorde Noise-Induced Building Vibrations, International Airport Dulles — Final Report.** NASA TM-74083, 1977. (N78-10839)

A series of studies were conducted to assess the noise-induced building vibrations associated with Concorde operations. The vibration levels of windows, walls, and floors were measured along with the associated noise levels of Concorde, subsonic aircraft, and some nonaircraft events. Test sites included Sully Plantation which is adjacent to Dulles International Airport and three residential homes located in Montgomery Contry, Maryland. The measured vibration response levels due to

Concorde operations were found to be (1) higher than the levels due to other aircraft, (2) less than the levels due to certain household events which involve direct impulsive loading such as door and window closing, (3) less than criteria levels for building damage, and (4) comparable to levels which are perceptible to people.

244 Staff, Langley Research Center: **Concorde Noise-Induced Building Vibrations, John F. Kennedy International Airport — Report Number 1.** NASA TM-78660, 1978. (N78-18873)

The outdoor and indoor noise levels resulting from aircraft flyovers and certain nonaircraft events were recorded at six home sites along with the associated vibration levels in the walls, windows, and floors of these test homes. Limited subjective tests conducted to examine the human detection and annoyance thresholds for building vibration and rattle caused by aircraft noise showed that both vibration and rattle were detected subjectively in several houses for some operations of both the Concorde and subsonic aircraft. Preliminary results indicate that the relationship between window vibration and aircraft noise is (1) linear with vibration levels being accurately predicted from OASPL levels measured near the window, (2) consistent from flyover to flyover for a given aircraft type under approach conditions, and (3) no different from Concorde than from other conventional jet transports (in the case of window vibrations induced under approach power conditions) the relatively high levels of window vibration measured during Concorde operations are due more to higher OASPL levels than to unique Concorde source characteristics.

245 Staff, Langley Research Center: **Concorde Noise-Induced Building Vibrations, John F. Kennedy International Airport — Report Number 2.** NASA TM-78676, 1978. (N78-20919)

Outdoor and indoor noise levels and associated vibration levels resulting from aircraft and nonaircraft events were recorded at eight homesites and a school. In addition, limited subjective tests were conducted to examine the human detection and annoyance thresholds for building vibration and rattle caused by aircraft noise. Presented herein are the majority of the window and wall vibration data recorded during Concorde and subsonic aircraft overflights.

246 Staff, Langley Research Center: **Concorde Noise-Induced Building Vibrations, John F. Kennedy International Airport — Report Number 3.** NASA TM-78727, 1978. (N78-26876)

Outdoor and indoor noise levels resulting from aircraft flyovers and certain nonaircraft events were recorded at eight homesites and a school along with the associated vibration levels in the walls, windows, and floors at these test sites. Limited subjective tests were conducted to examine the human detection and annoyance thresholds for building vibration and rattle caused by aircraft noise. Both vibration and rattle were detected subjectively in several houses for some operations of both the Concorde and subsonic aircraft. Seated subjects more readily detected floor vibrations than wall or window vibrations. Aircraft noise generally caused more window vibrations than common nonaircraft events such as walking and closing doors. Nonaircraft events and aircraft flyovers resulted in comparable wall vibration levels, while floor vibrations were generally greater for nonaircraft events than for aircraft flyovers. The relationship between structural vibration and aircraft noise is linear, with vibration levels being accurately predicted from overall sound pressure levels (OASPL) measured near the structure. Relatively high levels of structural vibration measured during Concorde operations are due more to higher OASPL levels than to unique Concorde-source characteristics.

247 Staff, Langley Research Center: **Noise-Induced Building Vibrations Caused by Concorde and Conventional Aircraft Operations at Dulles and Kennedy International Airports.** NASA TM-78769, 1978. (N78-33874)

Outdoor and indoor noise levels resulting from aircraft flyovers and certain nonaircraft events were recorded, as were the associated vibration levels in the walls, windows, and floors at building test sites. In addition, limited subjective tests were conducted to examine the human detection and annoyance thresholds for building vibration and rattle caused by aircraft noise. Representative peak levels of aircraft noise-induced building vibrations are reported and comparisons are made with structural damage criteria and with vibration levels induced by common domestic events. In addition, results of a pilot study are reported which indicate the human detection threshold for noise-induced floor vibrations.

248 Stroud, W. Jefferson; and Sobieszczanski-Sobieski, Jaroslaw: **Advanced Structural Sizing Methodology.** CTOL Transport Technology – 1978, NASA CP-2036, Pt. I, 1978, pp. 311-330. (In N78-27046)

Research in computerized structural sizing technology was reviewed. Areas covered include overall design, structural subassembly design, thermal structures, and stiffened panels. In each case, sample results are presented.

249 Tompkins, Stephen S.; Tenney, Darrel R.; and Unnam, Jalaiah: **Prediction of Moisture and Temperature Changes in Composites During Atmospheric Exposure.** NASA TM-78711, 1978. (N78-23149)

The effects of variations in diffusion coefficients, surface properties of the composite, panel tilt, ground reflection, and geographical location on the moisture concentration profiles and average moisture content of composite laminates were studied analytically. A heat balance which included heat input due to direct and sky diffuse solar radiation, ground reflection, and heat loss due to reradiation and convection was used to determine the temperature of composites during atmospheric exposure. The equilibrium moisture content was assumed proportional to the relative humidity of the air in the boundary layer of the composite. Condensation on the surface was neglected. Histograms of composite temperatures were determined and compared with those for the ambient environment.

250 *Waco, David E.: **Meteorological and Operational Aspects of 46 Clear Air Turbulence Sampling Missions With an Instrumented B-57B Aircraft.** Volume II (Appendix C) – Turbulence Missions. NASA TM-80045, 1979. (N79-27772)

The results of 46 clear air turbulence (CAT) probing missions conducted with an extensively instrumented B-57B aircraft are summarized from a meteorological viewpoint in a two-volume technical memorandum. The missions were part of the NASA Langley Research Center's MAT (Measurement of Atmospheric Turbulence) Program, which was conducted between March 1974, and September 1975, at altitudes ranging up to 15 km. Turbulence samples were obtained under diverse conditions including mountain waves, jet streams, upper level fronts and troughs, and low altitude mechanical and thermal turbulence. CAT was encountered on 20 flights comprising 77 data runs. In all, approximately 4335 km were flown in light turbulence, 1415 km in moderate turbulence and 255 km in severe turbulence during the program.

*Volume I by R. E. Davis et al. is entry 217.

251 Whitcomb, John D.: **Thermographic Measurement of Fatigue Damage.** NASA TM-78693, 1978. (N78-23457)

Heat generated by cyclic loading of fatigue damaged material raised surface temperatures. The temperatures were measured with an infrared camera. The measured temperatures were used as boundary conditions in a finite element heat transfer program, which was developed especially to calculate the extent of the heat generation zone, and thereby to define the fatigue damage zone. The finite element program was verified by comparing calculated heat generation with the actual heat generation for a simple heat transfer problem that has a closed form solution. The program was also checked by analyzing the thermogram of a composite specimen with an external heat source of known dimensions. From thermograms of test specimens, damage zones were calculated for $(0)_8$ $(45/90/\text{-}45/0)_s$, and $(45/9/\text{-}45/0)_s$ boron/epoxy fatigue specimens. Calculated damage zones were compared with damage detected by C-scan, X-ray, and SEM exmination. The analysis was effective in locating the boundaries of the fatigue damage zones.

252 Willis, Conrad M.: **Fluctuating Loads Measured on an Over-the-Wing Supersonic Jet Model.** NASA TP-1366, 1979. (N79-16641)

A test was conducted to measure fluctuating pressure loads on the wing and flap of an over-the-wing supersonic jet model. The model was tested statically and at a Mach number of 0.1 in a small free jet to simulate forward speed. Test parameters were impingement angle, nozzle height, and flap deflection. Load levels as high as 170 dB were measured at the center of the impingement region during static tests. Forward speed reduced the loading about 1 dB. Load level increased with increasing impingement angle and decreasing nozzle height above the wing. The effect of flap deflection was small. When scaled to full-size aircraft conditions, the maximum amplitude of the one-third-octave fluctuating pressure spectra was about 154 dB at about 160 Hz.

253 Yates, E. Carson, Jr.; and Morino, Luigi: **Geometry Requirements for Unsteady Aerodynamics in Aeroelastic Analysis and Design.** NASA TM-78781, 1978. (N78-33046)

Aircraft geometry requirements for unsteady aerodynamic computations are discussed and differences between requirements for steady and unsteady flow are emphasized within the framework of a general potential-flow aerodynamic formulation. Its implementation in a computer program called SOUSSA (steady, oscillatory, and unsteady subsonic and supersonic aerodynamics) is detailed.

254 Zorumski, William E.: **Prediction of Aircraft Sideline Noise Attenuation.** NASA TM-78717, 1978. (N78-27871)

A computational study is made using the recommended ground effect theory by Pao, Wenzel, and Oncley. It is shown that this theory adequately predicts the measured ground attenuation data by Parkin and Scholes, which is the only available large data set. It is also shown, however, that the ground effect theory does not predict the measured lateral attenuations from actual aircraft flyovers. There remain one or more important lateral effects on aircraft noise, such as sideline shielding of sources, which must be incorporated in the prediction methods. Experiments at low elevation angles (0° to 10°) and low-to-intermediate frequencies are recommended to further validate the ground effect theory.

NASA Contractor Reports

255 *Bacon, J. F.; Prewo, K. M.; and Thompson, E. R.: **Research on Graphite Reinforced Glass Matrix Composites.** NASA CR-158946, 1978. (N79-11126)

A composite that can be used at temperatures up to 857 K with mechanical properties equal or superior to graphite fiber reinforced epoxy composites is presented. The composite system consists of graphite fiber, uniaxially or biaxially, reinforced borosilicate glass. The mechanical and thermal properties of such a graphite fiber reinforced glass composite are described, and the system is shown to offer promise as a high performance structural material. A modified borosilicate glass uniaxially reinforced by Hercules HMS graphite fiber has a three-point flexural strength of 1030 MPa, a four-point flexural strength of 964 MPa, an elastic modulus of 199 GPa, and a failure strain of 0.0052. The preparation and properties of similar composites with Hercules NTS, Celanese CG-102, Thornel 300, and Thornel Pitch graphite fibers are also described.

*United Technologies Research Center, contract NAS1-14346.

256 *Blatz, P. S.: **NR-150B2 Adhesive Development.** NASA CR-3017, 1978. (N78-27273)

Adhesive based polyimide solutions which are more easily processed than conventional aromatic polyimide systems and show potential for use for extended times at 589 K are discussed. The adhesive system is based on a solution containing diglyme as the solvent and 2,2 bis (3',4'-dicarboxyphenyl) hexafluoropropane, paraphenylenediamine, and oxydianiline. The replacement of N-methylpyrrolidone with diglyme as the solvent was found to improve the adhesive strengths of lap shear samples and simplify the processing conditions for bonding both titanium and graphite fiber/polyimide matrix resin composites. Information was obtained on the effects of various environments including high humidity, immersion in jet fuel, and methylethylketone on aluminum filled adhesive bonds. The adhesive was also evaluated in wide area bonds and flatwise tensile specimens using titanium honeycomb and composite face sheets. It was indicated that the developed adhesive system has the potential for use in applications requiring long term exposure to at least 589 K (600° F).

*E. I. duPont de Nemours & Co., Inc., contract NAS1-14620.

257 *Boeing Commercial Airplane Co.: **Study of Advanced Composite Structural Design Concepts for an Arrow Wing Supersonic Transport Configuration.** NASA CR-145192, 1978. (N78-20112)

A structural design study was conducted to assess the relative merits of structural concepts using advanced composite materials for an advanced supersonic aircraft cruising at Mach 2.7. The configuration, and the structural arrangement developed during Task I and II of the study, was used as the baseline configuration. Allowable stresses and strains were established for boron and advanced graphite fibers based on projected fiber properties available in the next decade. Structural concepts were designed and analyzed using graphite polyimide and boron polyimide, applied to stiffened panels and conventional sandwich panels. The conventional sandwich panels were selected as the structural concept to be used on the wing structure. The upper and lower surface panels of the Task I arrow wing were redesigned using high-strength graphite polyim de sandwich panels over the titanium spars and ribs. The ATLAS computer system was used as the basis for stress analysis and resizing of the surface panels using the loads from the Task II study, without adjustment for change in aeroelastic deformation. The flutter analysis indicated a decrease in the flutter speed compared to the baseline titanium wing design. The flutter speed was increased to that of the titanium wing, with a weight penalty less than that of the metallic airplane.

*Boeing Commercial Airplane Co., contract NAS1-12287.

258 *Cornie, J. A.: **Characterization, Shaping, and Joining of SiC/Superalloy Sheet for Exhaust System Components.** NASA CR-135301, 1977. (N78-13134)

Hafnium carbide was shown to be virtually inert when in contact with silicon carbide and Waspalov for at least 200 hours at 1093° C (2000° F). Extensive interaction was noted with other superalloys such as HA-188. A continuous CVD HfC deposition process was developed for deposition of up to 8 μm of 0.14 mm (0.0056 in.) SiC tungsten core filament at rates as high as 0.6 m/min. The rate can be increased by increasing the length of the reactor and the output of the power supply used in resistive heating of the filament substrate. The strength of HfC coated filament varies with thickness in a Griffith-like manner. This strength reduction was greater for HfC coatings than for tungsten coatings, presumably because of the greater ductility of tungsten.

*Westinghouse Research & Development Center, contract NAS3-19735.

259 *Cotton, W. L.: **Effects of Service Environments on Aluminum-Brazed Titanium (ABTi).** NASA CR-2943, 1978. (N78-17188)

Aluminum brazed titanium (ABTi) structures were evaluated during prolonged exposure to extreme environments: elevated temperature exposure to airline service fluids, hydraulic fluid, and seawater, followed by laboratory corrosion tests. Solid-face and perforated-face honeycomb sandwich panel specimens, stressed panel assemblies, and faying surface brazed joints were tested. The corrosion resistance of ABTi is satisfactory for commercial airline service. Unprotected ABTi proved inherently resistant to attack by all of the extreme service aircraft environments except seawater at 700 K (800° F) and above, dripping phosphate ester hydraulic fluid at 505 K (450° F), and a marine environment at ambient temperature. The natural oxides and deposits present on titanium surfaces in airline service provide protection against hot salt corrosion pitting. Coatings are required to protect titanium dripping phosphate ester fluid at elevated temperatures and to protect exposed acoustic honeycomb parts against corrosion in a marine environment.

*Boeing Commercial Airplane Co., contract NAS1-13681.

260 *Crill, W.; and Dale, B.: **General Purpose Computer Program for Interacting Supersonic Configurations: Programer's Manual.** NASA CR-145127, 1977. (N79-18901)

The program ISCON (Interacting Supersonic Configuration) is described. The program is in support of the problem to generate a numerical procedure for determining the unsteady dynamic forces on interacting wings and tails in supersonic flow. Subroutines are presented along with the complete FORTRAN source listing.

*Textron Bell Aerospace Co., contract NAS1-13987.

261 *D'Auria, Patrick: **DYLOFLEX Modifications to FLEXSTAB (FLEXSTAB Volume II – User's Manual) (FLEXSTAB Volume III – Programmer's Manual).** NASA CR-2863, 1979. (N79-33160)

This document describes the required changes made to the SD&SS program of the FLEXSTAB Computer Program System allowing it to be interfaced with the DYLOFLEX Program System. Appendix A of this document describes the changes to specific pages in the FLEXSTAB User's Manual (NASA CR-114714). Appendix B describes the changes to specific pages in the FLEXSTAB Programmer's Manual (NASA CR-114715).

*Boeing Commercial Airplane Co., contract NAS1-13918.

262 *Dusto, Arthur R.; and Epton, Michael A.: **An Advanced Panel Method for Analysis of**

Arbitrary Configurations in Unsteady Subsonic Flow. NASA CR-152323, 1980.

An advanced method is presented for solving the linear integral equations for subsonic unsteady flow in three dimensions. The method is applicable to flows about arbitrary, nonplanar boundary surfaces undergoing small amplitude harmonic oscillations about their steady mean locations. The problem is formulated with a wake model wherein unsteady vorticity can be convected by the steady mean component of flow. The geometric location of the unsteady source and doublet distributions can be located on the actual surfaces of thick bodies in their steady mean locations. The method is an outgrowth of a recently developed steady flow panel method and employs the linear source and quadratic doublet splines of that method.

*Boeing Commercial Airplane Co., contract NAS2-7729.

263 *Harrison, B. A.; and Richard M.: **A Program To Compute Three-Dimensional Subsonic Unsteady Aerodynamic Characteristics Using the Doublet Lattice Method, L216 (DUBFLX).** Volume II: Supplemental System Design and Maintenance Document. NASA CR-2850, 1979. (In N79-31148)

This document contains a description of the information necessary for execution of the digital computer program L216 on the CDC 6600. L216 characteristics based on the doublet lattice method. Documentation consists of two parts: Volume I, Engineering and Usage; Volume II, Supplemental System Design and Maintenance.

*Boeing Commercial Airplane Co., contract NAS1-13918.

264 *Harvey, S. T.; and Michaelson, G. L.: **Advanced Composites Wing Study Program.** Volume I – Executive Summary. NASA CR-145382-1, 1978.

The effort necessary to achieve a state of production readiness for the design and manufacturing of advanced composite wing structure is outlined. Technical assessment and program options are also reviewed for the wing study results.

*Boeing Commercial Airplane Co., contract NAS1-15003.

265 *Harvey, S. T.; and Michaelson, G. L.: **Advanced Composites Wing Study Program.** Volume 2 – Final Report. NASA CR-145382-2, 1978. (N78-32186)

A study on utilization of advanced composites in commercial aircraft wing structures was conducted as a part of the NASA Aircraft Energy Efficiency Program to establish, by the mid-1980's, the technology for the design of a subsonic commercial transport aircraft leading to a 40 percent fuel savings. The study objective was to develop a plan to define the effort needed to support a production commitment for the extensive use of composite materials in wings of new generation aircraft that will enter service in the 1985-1990 time period. Identification and analysis of what was needed to meet the above plan requirements resulted in a program plan consisting of three key development areas: (1) technology development, (2) production capability development, and (3) integration and validation by designing, building, and testing major development hardware.

*Boeing Commercial Airplane Co., contract NAS1-15003.

266 *Kerr, J. R.; and Haskins, J. F.: **Time-Temperature-Stress Capabilities of Composite Materials for Advanced Supersonic Technology Application – Phase I.** NASA CR-159267, 1980.

Advanced composites will play a key role in the development of the technology required for the design and fabrication of future supersonic vehicles. However, implementation of the material into vehicle usage is contingent upon accelerating the demonstration of service capacity and design technology. Because of the added material complexity and lack of extensive service data, laboratory replication of the flight service will provide the most rapid method of documenting the airworthiness of advanced composite systems. A program is in progress to determine the time-temperature-stress capabilities of several high temperature composite materials. Tests included in this study are thermal aging, environmental aging, fatigue, creep, fracture, tensile, and real-time flight simulation exposure. The program has two parts. The first includes all the material property determinations and aging and simulation exposures up through 10 000 hours. The second continues these tests up to 50 000 cumulative hours. This report presents the results of the 10 000-hour phase, which has now been completed.

*General Dynamics Corp., contract NAS1-12308.

267 *Klarstrom, D. L.: **Thermomechanical Processing of HAYNES® Alloy No. 188 Sheet To Improve Creep Strength.** NASA CR-3013, 1978. (N78-32231)

Improvements in the low strain creep strength of HAYNES® alloy No. 188 thin gauge sheet by means of thermomechanical processing were developed. Processing methods designed to develop a sheet with strong crystallographic texture after recrystallization and to optimize grain size were principally studied. The effects of thickness-to-grain-diameter ratio and prestrain on low strain creep strength were also briefly examined. Results indicate that the most significant improvements were obtained in the sheets having a strong crystallographic texture. The low strain creep strength of the textured sheets was observed to be superior to that of standard production sheets in the 922 K to 1255 K temperature range. Tensile, stress rupture, fabricability, and surface stability properties of the experimental sheets were also measured and compared to property values reported for the baseline production sheets.

*Cabot Corp., contract NAS1-13837.

268 *Kroll, Richard I.; and Miller, Ronald D.: **Comparisons of Several Aerodynamic Methods for Application to Dynamic Loads Analyses.** NASA CR-137720, 1976. (N77-13001)

The results of a study are presented in which the applicability at subsonic speeds of several aerodynamic methods for predicting dynamic gust loads on aircraft, including active control systems, was examined and compared. These aerodynamic methods varied from steady state to an advanced unsteady aerodynamic formulation. Brief descriptions of the structural and aerodynamic representations and of the motion and load equations are presented. Comparisons of numerical results achieved using the various aerodynamic methods are shown in detail. From these results, aerodynamic representations for dynamic gust analyses are identified. It was concluded that several aerodynamic methods are satisfactory for dynamic gust analyses of configurations having either controls fixed or active control systems that primarily affect the low frequency rigid body aircraft response.

*Boeing Commercial Airplane Co., contract NAS2-7729.

269 *Leis, B. N.; and Sampath, S. G.: **Development of an Improved Method of Consolidating Fatigue Life Data.** NASA CR-145312, 1978. (N78-22401)

A fatigue data consolidation model that incorporates recent advances in life prediction methodology was developed. A combined analytic and experimental study of fatigue of notched 2024-T3 aluminum alloy under constant anplitude loading was carried out. Because few systematic and complete data sets for 2024-T3 were available the program generated data for fatigue crack initiation and separation failure for both zero and nonzero mean stresses. Consolidations of these data are presented.

*Battelle Columbus Laboratories, contract NAS1-14171.

270 *Lunde, Tjerand: **Real-Time Testing of Titanium Sheet and Extrusion Coupon Specimens Subjected to Mach 2.7 Supersonic Cruise Aircraft Wing Stresses and Temperatures.** NASA CR-2754, 1977. (N78-13478)

The accuracy of three accelerated flight-by-flight test methods for material selection and fatigue substantiation of supersonic cruise aircraft structure was studied. The real-time stresses and temperatures applied to the specimens were representative of the service conditions in the lower surface of a Mach 2.7 supersonic cruise aircraft wing root structure. Each real-time flight lasted about 65 minutes, including about 1 hour at 500° F in the cruise condition. Center notched coupon specimens from six titanium materials were tested: mill-annealed, duplex-annealed, and triplex-annealed Ti-8Al-1M8-1V sheets; mill-annealed Ti-8Al-1M8-1V extrusion; mill-annealed Ti-6Al-4V sheet; and solution-treated and aged Ti-6Al-4V extrusion. For duplex-annealed Ti-8Al-1M8-1V sheet, specimens with single spotweld were also tested. The test results were studied in conjunction with other related data from the literature for material selection, structural fabrication, fatigue resistance of supersonic cruise aircraft structure, and fatigue test acceleration procedures for supersonic cruise aircraft.

*Lockheed-California Co., contract NAS3-17866.

271 *Mark, William D.: **Characterization of Nongaussian Atmospheric Turbulence for Prediction of Aircraft Response Statistics.** NASA CR-2913, 1977. (N78-16044)

Mathematical expressions were derived for the exceedance rates and probability density functions of aircraft response variables using a turbulence model that consists of a low frequency component plus a variance modulated Gaussian turbulence component. The functional form of experimentally observed concave exceedance curves was predicted theoretically, the strength of the concave contribution being governed by the coefficient of variation of the time fluctuations variance of the turbulence. Differences in the functional forms of response exceedance curves and probability densities also were shown to depend primarily on this same coefficient of variation. Criteria were established for the validity of the local stationary assumption that is required in the derivations of the exceedance curves and probability density functions. These criteria are shown to depend on the relative time scale of the fluctuations in the variance, the fluctuations in the turbulence itself, and on the nominal duration of the relevant aircraft impulse response function. Metrics that can be generated from turbulence recordings for testing the validity of the local stationary assumption were developed.

*Bolt, Beranek and Newman, Inc., contract NAS1-14412.

272 *Miller, R. D.; Kroll, R. I.; and Clemmons, R. E.: **Dynamic Loads Analysis System (DYLOFLEX) Summary.** Volume I: Engineering Formulation. NASA CR-2846-1, 1979. (N79-31144)

This document describes the dynamic loads analysis system DYLOFLEX. DYLOFLEX was developed to expand the aeroelastic cycle from that in the FLEXSTAB computer program system to include dynamic loads analyses involving active controls. Two aerodynamic options exist within DYLOFLEX. The analyst can formulate the problem with unsteady aerodynamics calculated using the doublet lattice method or with quasi-steady aerodynamics formulated from either FLEXSTAB or doublet lattice steady state aerodynamics with unsteady effects approximated by indicial lift growth functions. The equations of motion are formulated assuming straight and level flight and small motions. Loads are calculated using the force summation technique. DYLOFLEX consists of nine stand-alone programs which can be linked with each other by magnetic files used to transmit the required data between programs.

*Boeing Commercial Airplane Co., contract NAS1-13918.

273 *Miller, R. D.; Kroll, R. I.; and Clemmons, R. E.: **Dynamic Loads Analysis System (DYLOFLEX) Summary.** Volume II: Supplemental System Design Information. NASA CR-2846-2, 1979. (N79-31145)

This document contains supplemental information concerning the design and use of the program system. See Abstract for NASA CR-2846-1, entry 272.

*Boeing Commercial Airplane Co., contract NAS1-13918.

274 *Morino, Luigi: **Steady, Oscillatory, and Unsteady Subsonic and Supersonic Aerodynamics — Production Version (SOUSSA-P 1.1).** Volume I — Theoretical Manual. NASA CR-159130, 1980.

A review and summary of recent developments of the Green's function method and the computer program SOUSSA (Steady, Oscillatory, and Unsteady Subsonic and Supersonic Aerodynamics) are presented. Applying the Green's function method to the fully unsteady (transient) potential equation yields an integro-differential-delay equation. With spatial discretization by the finite-element method, this equation is approximated by a set of differential-delay equations in time. Time solution by Laplace transform yields a matrix relating the velocity potential to the normal wash. Premultiplying and postmultiplying by the matrices relating generalized forces to the potential and the normal wash to the generalized coordinates, one obtains the matrix of the generalized aerodynamic forces. The frequency and mode-shape dependence of this matrix makes the program SOUSSA very useful for multiple frequency and repeated mode-shape evaluations. The program SOUSSA is general, flexible, easy to use, and accurate. Applications to aerodynamic design are also discussed. The user/programmer manual for SOUSSA-P 1.1 is presented in Volume 2 of this report (NASA CR-159131, entry 286).

*Aerospace Systems, Inc., contract NAS1-14977.

275 *Payne, L.: **Fabrication and Evaluation of Advanced Titanium Structural Panels for Supersonic Cruise Aircraft.** NASA CR-2744, 1977. (N79-18320)

Flightworthy primary structural panels were designed, fabricated, and tested to investigate two advanced fabrication methods for titanium alloys. Skin-stringer panels fabricated using the weldbraze process and honeycomb-core sandwich panels fabricated using a diffusion bonding process, were designed to replace an existing integrally stiffened shear panel on the upper wing surface of the NASA YF-12 research aircraft. The investigation included ground testing and Mach 3 flight testing of full-scale panels and laboratory testing of representative structural element specimens. Test results obtained on full-scale panels and structural element specimens indicate that both of the fabrication methods investigated are suitable for primary structural applications on future civil and military supersonic cruise aircraft.

*Lockheed-California Co.

276 *Richard, M.; and Harrison, B. A.: **A Program To Compute Three-Dimensional Subsonic Unsteady Aerodynamic Characteristics Using the Doublet Lattice Method, L216 (DUBFLX).** Volume I: Engineering and Usage. NASA CR-2849, 1979. (N79-32163)

This document contains a description of the information necessary for execution of the digital computer program L216 (DUBFLX) on the CDC 6600. L216 has the capability to compute subsonic unsteady aerodynamic characteristics based on the doublet lattice method. Arbitrary aerodynamic configurations may be represented with combinations of nonplanar lifting surfaces composed of finite constant pressure panel elements, and axially symmetric slender bodies composed of constant pressure line elements. Program input consists of configuration geometry, aerodynamic parameters, and modal data; output includes element geometry, pressure difference distributions, integrated aerodynamic coefficients, stability derivatives, generalized aerodynamic forces, and aerodynamic influence coefficient matrices. Optionally, modal data may be input on magnetic file (tape or disk), and certain geometric and aerodynamic output may be saved for subsequent use. Documentation consists of two parts: Volume I, Engineering and Usage; Volume II, System Design and Maintenance.

*Boeing Commercial Airplane Co., contract NAS1-13918. Volume II by Harrison and Richard is entry 263.

277 *Ross, Irving; and Edson, Ralph: **An Electronic Control for an Electrohydraulic Active Control Aircraft Landing Gear.** NASA CR-3113, 1979. (N79-23948)

An electronic controller for an electrohydraulic active control aircraft landing gear was developed. Drop tests of a modified gear from a 2722 kg (6000 lbm) class of airplane were conducted to illustrate controller performance. The results indicate that the active gear effects a force reduction, relative to that of the passive gear, from 9 to 31 percent depending on the aircraft sink speed and the static gear pressure.

*Hydraulic Research Textron, contract NAS1-14459.

278 *Ruo, S. Y.: **Improved Sonic-Box Computer Program for Calculating Transonic Aerodynamic Loads on Oscillating Wings With Thickness.** NASA CR-158906, 1978. (N79-10998)

A computer program was developed to account approximately for the effects of finite wing thickness in transonic potential flow over an oscillating wing of finite span. The program is based on the original sonic box computer program for a planar wing which was extended to account for the effect of wing thickness. Computational efficiency and accuracy were improved and swept trailing edges were accounted for. The nonuniform flow caused by finite thickness was taken into account by application of the local linearization concept with appropriate coordinate transformation. A brief description of each computer routine and the applications of cubic spline and spline surface data fitting techniques used in the program are discussed.

*Lockheed-Georgia Co., contract NAS1-13613.

279 *Ruo, S. Y.: **Sonic-Box Method Employing Local Mach Number for Oscillating Wings With Thickness.** NASA CR-158907, 1978. (N79-10999)

A computer program was developed to account approximately for the effects of finite wing thickness in the transonic potential flow over an oscillating wing of finite span. The program is based on the original sonic-box program for a planar wing which was previously extended to include the effects of the swept trailing edge and the thickness of the wing. The nonuniform flow caused by finite thickness is taken into account by application of the local linearization concept. The thickness effect, expressed in terms of the local Mach number, is included in the basic solution to replace the coordinate transformation method used in the earlier work. Calculations were made for a delta wing and a rectangular wing performing plunge and pitch oscillations, and the results were compared with those obtained from other methods. An input guide and a complete listing of the computer code are presented.

*Lockheed-Georgia Co., contract NAS1-13613.

280 *Sakata, I. F.; and Davis, G. W.: **Evaluation of Structural Design Concepts for an Arrow-Wing Supersonic Cruise Aircraft.** NASA CR-2667, 1977. (N77-25581)

An analytical study was performed to determine the best structural approach for design of primary wing and fuselage structure of a Mach 2.7 arrow wing supersonic cruise aircraft. Concepts were evaluated considering near term start of design. Emphasis was placed on the complex interactions between thermal stress, static aeroelasticity, flutter, fatigue and fail safe design, static and dynamic loads, and the effects of variations in structural arrangements, concepts, and materials on these interactions. Results indicate that a hybrid wing structure incorporating low profile convex beaded and honeycomb sandwich surface panels of titanium alloy 6Al-4V was the most efficient. The substructure includes titanium alloy spar caps reinforced with boron polyimide composites. The fuselage shell consists of hat-stiffened skin and frame construction of titanium alloy 6Al-4V. A summary of the study effect is presented, and a discussion of the overall logic, design philosophy, and interaction between the analytical methods for supersonic cruise aircraft design is included.

*Lockheed-California Co., contract NAS1-12288.

281 *Sakata, I. Frank; Ostrom, Robert B.; and Cardinale, Sal V.: **Utilization of Advanced Composites in Commercial Aircraft Wing Structures — Executive Summary.** NASA CR-145381-1, 1978. (N78-32187)

The effort required by commercial transport manufacturers to accomplish the transition from current construction materials and practices to extensive use of composites in aircraft wings was investigated. The engineering and manufacturing disciplines which normally are involved in the design, development, and production of an aircraft were included to ensure that all of the factors that would enter a decision to commit to production of a composite wing structure were addressed. A conceptual design of an advanced technology reduced energy aircraft provided the framework for identifying and investigating unique design aspects. A plan development effort defined the essential technology needs and formulated approaches for effecting the required wing development. The wing development program plans, resource needs, and recommendations are summarized.

*Lockheed-California Co., contract NAS1-15005.

282 *Sakata, I. Frank; and Ostrom, Robert B.: **Utilization of Advanced Composites in Commercial Aircraft Wing Structures.** NASA CR-145381-2, 1978. (N78-32188)

A plan is defined for a composite wing development effort which will assist commercial transport manufacturers in reaching a level of technology réadiness where the utilization of composite wing structure is a cost competitive option for a new aircraft production plan. The recommended development effort consists of two programs: a joint government/industry material development program and a wing structure development program. Both programs are described in detail.

*Lockheed-California Co., contract NAS1-15005.

283 *Schaedel, Stephen F.: **Human Factors in Design of Passenger Seats for Commercial Aircraft — A Review.** NASA CR-152627, 1977. (N77-20775)

Seat comfort and safety research since the early part of the century is reviewed. The approach blends empirical and theoretical human factors and technical knowledge of seated humans under static and dynamic conditions experienced on commercial aircraft.

*University of Virginia, grant NGR-47-005-181.

284 *Sidwell, Kenneth: **A Mathematical Study of a Random Process Proposed as an Atmospheric Turbulence Model.** NASA CR-145200, 1977. (N77-26897)

A random process is formed by the product of a local Gaussian process and a random amplitude process and the sum of that product with an independent mean value process. The mathematical properties of the resulting process are developed, including the first and second order properties and the characteristic function of general order. An approximate method for the analysis of the response of linear dynamic systems to the process is developed. The transition properties of the process are also examined.

*Joint Inst. for Advancement of Flight Sciences, *grant* NGR-09-010-078.

285 *Sidwell, Kenneth: **A Qualitative Assessment of a Random Process Proposed as an Atmospheric Turbulence Model.** NASA CR-145247, 1977. (N77-33145)

A random process is formed by the product of two Gaussian processes and the sum of that product with a third Gaussian process. The resulting total random process is interpreted as the sum of an amplitude modulated process and a slowly varying, random mean value. The properties of the process are examined, including an interpretation of the process in terms of the physical structure of atmospheric motions. The inclusion of the mean value variation gives an improved representation of the properties of atmospheric motions, since the resulting process can account for the differences in the statistical properties of atmospheric velocity components and their gradients. The application of the process to atmospheric turbulence problems, including the response of aircraft dynamic systems, is examined. The effects of the mean value variation upon aircraft loads are small in most cases, but can be important in the measurement and interpretation of atmospheric turbulence data.

*Joint Inst. for Advancement of Flight Sciences, grant NGR-09-010-078.

286 *Smolka, Scott A.; Preuss, Robert D.; Tseng, Kadin; and Morino, Luigi: **Steady, Oscillatory, and Unsteady Subsonic and Supersonic Aerodynamics — Production Version 1.1 (SOUSSA-P 1.1).** Volume II — User/Programmer Manual. NASA CR-159131, 1980.

The theoretical formulation upon which the program is based is described in a companion manual, NASA CR-159130 (entry 274). The overall objective in designing the program was to provide accurate and efficient evaluation of steady and unsteady loads on aircraft having arbitrary shapes and motions, including structural deformations. The SOUSSA-P 1.1 program was therefore designed to be modular, computationally efficient, user oriented, general, accurate, and simple. These design goals were in part achieved through the incorporation of the data handling capabilities of the SPAR Finite-Element Structural Analysis computer program. As a further result, SOUSSA-P possesses an extensive checkpoint/restart facility. The programmer's portion of this manual includes the following: overlay/subroutine hierarchy, logical flow of control, definition of SOUSSA-P 1.1 FORTRAN variables, and definition of SOUSSA-P 1.1 subroutines. The user-oriented portion of the manual describes the following: purpose of the SOUSSA-P 1.1 modules, input data to the program, output of the program, hardware/software requirements, error detection and reporting capabilities, job control statements, a summary of the procedure for running the program, and two test cases including input and output listings.

*Aerospace Systems, Inc., contract NAS1-14977.

287 *Stone, Robert H.: **Development of Graphite/Polyimide Honeycomb Core Materials.** NASA CR-158921, 1978. (N78-33148)

Honeycomb panel constructions consisting entirely of graphite/polyimide composites were developed and evaluated. Graphite/polyimide composites were used in the honeycomb core webs and in pre-cured sandwich skins. Polyimide adhesives were also developed and evaluated for use in skin-core bonding. The purpose of this program was to develop lightweight sandwich constructions for high temperature applications which could provide comparable shear strength and stiffness to metallic honeycomb constructions.

*Lockheed-California Co.

288 *Takekoshi, T.; Hillig, W. B.; Mellinger, G. A.; et al.: **Study of Improved Resins for Advanced Supersonic Technology Composites.** Part I. Heterocromatic Polymers Containing Ether Groups. Part II. Curing Chemistry of Aromatic Polymers and Composite Studies. NASA CR-145007, 1976. (N77-13157)

Fourteen ether-containing, aromatic dianhydrides have been synthesized from N-phenyl-3 or 4-nitrophthalimide and various bisphenols. The process involves nucleophilic displacement of activated nitro groups with bisphenolate ions. Ether-containing dianhydrides were indefinitely stable in the presence of atmospheric moisture. One-step, high temperature solution polymerization of the ether-containing dianhydrides with m-phenylene diamine, 4,4'-oxydianiline and 1, 3-bis (4-aminophenoxy) benzene afforded 42 polyetherimides. The polyetherimides were all soluble in m-cresol except two which were found to be crystalline. The glass transition temperatures of the polyetherimides ranged from 178° C to 277° C. Soluble polybenzimidazopyrrolones-containing ether groups were also prepared from the same ether-containing dianhydrides and aromatic tetraamines by one-step solution polymerization. Using low molecular weight polyetherimides, various thermoset resin systems were developed and tested as matrices for fiber-reinforced composites. The curing chemistry involving reaction of the phthalonitrile group and the o-diaminophenyl group was found to be generally applicable to cross-linking various aromatic polymers and other than polyimides.

*General Electric Co., contract NAS1-12079. Omitted in previous bibliography.

289 *Takekoshi, T.; Mellinger, G. A.; Bulson, R. W.; Ladd, J. R.; and Webber, M. J.: **Study of Improved Resins for Advanced Supersonic Technology Composites — Part III.** Phthalonitrile-Capped Polyetherimides as Matrix Resin for Graphite Fiber Composites. NASA CR-145237, 1977. (X78-10124)

Various low molecular weight polyetherimides containing end groups (PEI-CN resin) were prepared using (aminophenoxy) enthalonitrile as a capping agent. The PEI-CN resin had good solubility and a low melt viscosity and cured on heating above 200° C. A mixture of PEI-CN and TAB was formulated in m-cresol. Graphite fiber composite plaques of various sizes were fabricated from the formulation. Thin film samples of cured PEI-CN resin were subjected to thermal stability tests. The weight loss after an exposure of 500 hours to air was 13 percent at 320° C and 2.5 percent at 288° C. In addition to the above resin system, preliminary investigations on two additional resin systems were carried out. The first system involves a low molecular weight polyetherimide containing an average of three enthalonitrile groups per molecule. The second system was composed of single component amineterminated oligomides which were derived from 3,3′-diaminobenzopenone.

*General Electric Co., contract NAS1-12079.

290 *Trevino, George: **On the Spectrum of Inhomogeneous Turbulence.** NASA CR-162137, 1979. (N79-30987)

Inhomogeneous turbulence is defined as turbulence whose statistics are functions of spatial position. The turbulence spectrum, and particularly how the shape of the spectrum varies from point to point in space as a consequence of well-defined spatial variations in the turbulence intensity and/or integral scale, is investigated.

*Del Mar College, Grant 1615.

291 *Turner, M. J.; and Grande, D. L.: **Study of Advanced Composite Structural Design Concepts for an Arrow Wing Supersonic Cruise Configuration.** NASA CR-2825, 1978. (N78-20116)

Based on estimated graphite and boron fiber properties, allowable stresses and strains were established for advanced composite materials. Stiffened panel and conventional sandwich panel concepts were designed and analyzed using graphite/polyimide and boron/polyimide materials. The conventional sandwich panel was elected as the structural concept for the modified wing structure. Upper and lower surface panels of the arrow wing structure were then redesigned using high strength graphite/polyimide sandwich panels and retaining the titanium spars and ribs from the prior study. The ATLAS integrated analysis and design system was used for stress analysis and automated resizing of surface panels. Flutter analysis of the hybrid structure showed a significant decrease in flutter speed relative to the titanium wing design. The flutter speed was increased to that of the titanium design by selective increase in laminate thickness and by using graphite fibers with properties intermediate between high strength and high modulus values.

*Boeing Commercial Airplane Co., contract NAS1-12287.

292 *Turner, M. J.; and Grande, D. L.: **Study of Metallic Structural Design Concepts for an Arrow Wing Supersonic Cruise Configuration.** NASA CR-2743, 1977. (N78-16043)

A structural design study was made to assess the relative merits of various metallic structural concepts and materials for an advanced supersonic aircraft cruising at Mach 2.7. Preliminary studies were made to ensure compliance of the configuration with general design criteria, to integrate the propulsion system with the airframe, to select structural concepts and materials, and to define an efficient structural arrangement. An advanced computerized structural design system was used in conjunction with a relatively large, complex finite element model, for detailed analysis and sizing of structural members to satisfy strength and flutter criteria. A baseline aircraft design was developed for assessment of current technology. Criteria, analysis methods, and results are presented. The effect on design methods of using the computerized structural design system was appraised, and recommendations are presented concerning further development of design tools, development of materials and structural concepts, and research on basic technology.

*Boeing Commercial Airplane Co., contract NAS1-12287.

293 *Waterman, A. W.: **Testing of Polyimide Second-Stage Rod Seals for Single-Stage Applications in Advanced Aircraft Hydraulic Systems.** NASA CR-135191, 1977. (N77-23493)

Machined polyimide second-stage rod seals were evaluated to determine their suitability for single-stage applications where full system pressure acts on the upstream side of the seal. The 6.35-cm (2.5-in.) K-section seal was tested in impulse screening tests where peak pressure was increased in 3.448-MPa (500-psi) increments each 20 000 cycles. Seal failure occurred at 37.92 MPa (5500 psi), indicating a potential for acceptability in a 27.58-MPa (4000-psi) system. Static pressurization for 600 sec at pressures in excess of 10.34 MPa (1500 psi) revealed structural inadequacy of the seal cross section to resist fracture and extrusion. Endurance testing showed the seals capable of at least 65 000, 1.27-cm (0.5-in.) cycles at 450 K (340° F) without leakage. It was concluded that the second-stage seals were proven to be exceptional in the 1.379-MPa (200-psi) applications for which they were designed, but polyimide material properties are not adequate for use in this design at pressure loading equivalent to that present in single-stage applications.

*Boeing Commercial Airplane Co., contract NAS3-18529.

294 *Watts, D. J.: **A Study on the Utilization of Advanced Composites in Commercial Aircraft Wing Structure — Executive Summary.** NASA CR-158902-1, 1978. (N79-20189)

The overall wing study objectives are to study and plan the effort by commercial transport aircraft manufacturers to accomplish the transition from current conventional materials and practices to extensive use of advanced composites in wings of aircraft that will enter service in the 1985–1990 time period. Specific wing study objectives are to define the technology and data needed to support an aircraft manufacturer's commitment to utilize composite primary wing structure in future production aircraft and to develop plans for a composite wing technology program which will provide the needed technology and data.

*Douglas Aircraft Co., contract NAS1-15004.

295 *Watts, D. J.: **A Study on the Utilization of Advanced Composites in Commercial Aircraft Wing Structure.** NASA CR-158902-2, 1978. (N79-20190)

A study was conducted to define the technology and data needed to support the introduction of advanced composite materials in the wing structure of future production aircraft. The study accomplished the following: (1) definition of acceptance factors, (2) identification of technology issues, (3) evaluation of six candidate wing structures, (4) evaluation of five program options, (5) definition of a composite wing technology development plan, (6) identification of full-scale tests, (7) estimation of program costs for the total development plan, (8) forecast of future utilization of composites in commercial transport aircraft, and (9) identification of critical technologies for timely program planning.

*Douglas Aircraft Co., contract NAS1-15004.

296 *Weatherill, Warren H.; Sebastian, James D.; and Ehlers, F. Edward: **The Practical Application of a Finite Difference Method for Analyzing Transonic Flow Over Oscillating Airfoils and Wings.** NASA CR-2933, 1978. (N78-16999)

Separating the velocity potential into steady and unsteady parts and linearizing the resulting unsteady equations for small disturbances was performed. Since sinusoidal motion is assumed, the unsteady equation is independent of time. The results of an investigation into the relaxation-solution-instability problem were discussed. Concepts examined include variations in outer boundary conditions, a coordinate transformation so that the boundary condition at infinity may be applied to the outer boundaries of the finite difference region, and overlapping subregions. The general conclusion was that only a full direct solution in which all unknowns are obtained at the same time will avoid the solution instabilities of relaxation. Pressure distributions were presented for a low-aspect-ratio clipped delta wing at a Mach number of 0.9 and for a moderate-aspect-ratio rectangular wing at a Mach number of 0.875.

*Boeing Commercial Airplane Co., contract NAS1-14204.

297 *Webb, B. A.; and Dolowy, J. F., Jr.: **Brazed Bonding of Borsic/Aluminum Composite Sheet to Titanium.** NASA CR-133730, 1975. (N76-13499)

Braze bonding studies between Borsic/aluminum composite and titanium sheet were conducted to establish acceptable brazing techniques and to assess potential joint efficiencies. Excellent braze joints were produced which exhibited joint strengths exceeding 117 MPa (17 000 psi) and which retained up to 2/3 of this strength at 589 K (600° F). Noticeable composite strength degradation resulting from the required high temperature braze cycle was found to be a problem.

*DRW Composite Specialties, Inc., contract NAS1-13095. Omitted in previous bibliography.

298 *Wrenn, G. A.; McCullers, L. A.; and Newsom, J. R.: **Structural and Aeroelastic Studies of a Supersonic Arrow-Wing Configuration.** NASA CR-145325, 1978. (X78-10014)

Structural and aeroelastic analyses performed on a detailed finite element simulation of the AST-102 are documented. This Mach 2.7 cruise arrow-wing commercial transport configuration was developed as part of the Supersonic Cruise Aircraft Research Program conducted by NASA. Studies were conducted on the effect of engine mass and location and horizontal tail area on the wing flutter characteristics. Other studies concerned a potential ground clearance problem at the wing tip during landing and the loss of control surface effectiveness due to wing flexibility. A study was also conducted to determine the feasibility of using active controls for wing flutter suppression.

*Vought Corp., contract NAS1-13500.

Articles, Meeting Papers, and Company Reports

299 Abel, Irving; Perry, Boyd, III; and Murrow, Harold N.: **Two Synthesis Techniques Applied to Flutter Suppression on a Flight Research Wing.** J. Guid. & Control, vol. 1, no. 5, Sept.–Oct. 1978, pp. 341-346.

300 Adelman, Howard M.; Sawyer, Patricia L.; and Shore, Charles P.: **Development of Methodology for Optimum Design of Structures at Elevated Temperatures.** A Collection of Technical Papers – AIAA/ASME 19th Structures, Structural Dynamics and Materials Conference, Apr. 1978, pp. 23-36. (In A78-29776)

Available as AIAA Paper 78-468. (A78-29779)

301 Anderson, Melvin S.; and Stroud, W. Jefferson: **A General Panel Sizing Computer Code and Its Application to Composite Structural Panels.** A Collection of Technical Papers – AIAA/ASME 19th Structures, Structural Dynamics and Materials Conference, Apr. 1978, pp. 14-22. (In A78-29776)

Available as AIAA Paper 78-467. (A78-29778)

302 Carden, Huey D.; and McGehee, John R.: **Validation of a Flexible Aircraft Takeoff and Landing Analysis (FATOLA) Computer Program Using Flight Landing Data.** Volume B – Dynamics, Structural Dynamics, AIAA/ASME 18th Structures, Structural Dynamics & Materials Conference, Mar. 1977, pp. 83-88. (In A77-25778)

Available as AIAA Paper 77-404. (A77-25787)

303 Chang, B.; Stolpestad, H.; Shinozuka, M.; and Vaicaitis, R.: **Improved Methods for Predicting Spectrum Loading Effects – Phase I Report.** Volume I – Results and Discussion. AFFDL-TR-79-3036, U.S. Air Force, Jan. 1979. (N80-11071)

Available from DTIC as AD A072 386.

304 Doggett, Robert V., Jr.; and Ricketts, Rodney H.: **Some Experimental and Theoretical Flutter Characteristics of an Arrow-Wing Configuration.** Volume B – Dynamics, Structural Dynamics, AIAA/ASME 18th Structures, Structural Dynamics & Materials Conference, Mar. 1977, pp. 127-132. (In A77-25778)

Available as AIAA Paper 77-422. (A77-25792)

305 Dusto, A. R.; Epton, M. A.; and Johnson, F. T.: **Advanced Panel Type Influence Coefficient Methods Applied to Unsteady Three Dimensional Potential Flows.** AIAA Paper 78-229, Jan. 1978. (A78-52630)

306 Ehlers, F. E.; Epton, M. A.; Johnson, F. T.; Magnus, A. E.; and Rubbert, P. E.: **An Improved**

Higher Order Panel Method for Linearized Supersonic Flow. AIAA Paper 78-15, Jan. 1978. (A78-52628)

307 George, M. F., Jr.; and Burton, R. V., Jr.: **Fuel Tank Sealant Requirements for Advance High Performance Aircraft.** AIAA Paper 79-0807, Apr. 1979. (A79-28288)

308 Gross, D. W.: **A Multi-Disciplinary Approach to Structural Design for Stochastic Loads.** AIAA Paper 79-0238, Jan. 1979. (A79-19613)

309 *Hamilton, C. H.; Stacher, G. W.; Mills, J. A.; and Li, H. W.: **Superplastic Forming of Titanium Structures.** AFML-TR-75-62, U.S. Air Force, Apr. 1975. (X76-75270)

Available from DTIC as AD B006 891.

*Omitted in previous bibliography.

310 Haskins, J. F.; Kerr, J. R.; and Stein, B. A.: **Flight Simulation Testing of Advanced Composites for Supersonic Cruise Aircraft Applications.** Volume A – Structures and Materials, AIAA/ASME 18th Structures, Structural Dynamics & Materials Conference, Mar. 1977, pp. 236-245. (In A77-25726)

Available as AIAA Paper 77-401. (A77-25753)

311 Hinkle, T. V.: **Effect of Service Environment on F-15 Boron/Epoxy Stabilator.** AFFDL-TR-79-3072, U.S. Air Force, June 1979. (N80-17064)

Available from DTIC as AD A076 493.

312 Kennedy, John M.; Tenney, Darrel R.; and Herakovich, Carl T.: **Tensile and Compressive Stress-Strain Behavior of Heat-Treated Boron-Aluminum.** NASA paper presented at the Second International Conference on Composite Materials (Toronto, Canada), Apr. 1978. (A78-37675)

313 Lan, C. Edward; and Mehrotra, Sudhir C.: **Improved Woodward's Panel Method for Calculating Edge Suction Forces.** J. Aircr., vol. 16, no. 9, Sept. 1979, pp. 632-635.

314 Liu, A. F.; and Dittmer, D. F.: **Effect of Multiaxial Loading on Crack Growth.** Volume III – Compilation of Interferometry Photographs. AFFDL-TR-78-175, U.S. Air Force, Dec. 1978. (N80-11512)

Available from DTIC as AD A072 074.

315 McGehee, J. R.; Carden, H. D.; and Edson, R.: **Improved Aircraft Dynamic Response and Fatigue Life During Ground Operations Using an Active Control Landing Gear System.** AIAA Paper 78-1499, Aug. 1978. (A78-47939)

316 Morino, L.; and Tseng, K.: **Time-Domain Green's Function Method for Three-Dimensional Nonlinear Subsonic Flows.** AIAA Paper 78-1204, July 1978. (A78-41894)

317 Morino, L.; and Tseng, K.: **Unsteady Subsonic and Supersonic Potential Aerodynamics for Complex Configurations.** Proceedings of International Symposium on Innovative Numerical Analysis in Applied Engineering Science, Cent. Tech. Ind. Mec. (France), 1977, pp. 4-27 – 4-30. (In A79-12351)

318 Morino, Luigi; and Tseng, Kadin: **Steady, Oscillatory and Unsteady, Subsonic and Supersonic Aerodynamics (SOUSSA) for Complex Aircraft Configurations.** Unsteady Aerodynamics, AGARD-CP-227, Feb. 1978, pp. 3-1 – 3-14. (In N78-22033)

319 Murrow, H. N.; and Eckstrom, C. V.: **Drones for Aerodynamic and Structural Testing (DAST) – A Status Report.** AIAA Paper 78-1485, Aug. 1978. (A78-47929)

320 Narayanaswami, R.; and Adelman, Howard M.: **Evaluation of the Tensor Polynomial and Hoffman Strength Theories for Composite Materials.** J. Compos. Mater., vol. 11, Oct. 1977, pp. 366-377.

321 Oman, B. H.; Kruse, G. S.; and Schrader, O. E.: **The Vehicle Design Evaluation Program – A Computer-Aided Design Procedure for Transport Aircraft.** SAWE Paper 1158, May 1977. (A78-17891)

322 Ricketts, Rodney H.; and Sobieszczanski, Jaroslaw: **Simplified and Refined Structural Modeling for Economical Flutter Analysis and Design.** Volume B – Dynamics, Structural Dynamics, AIAA/ASME 18th Structures, Structural Dynamics & Materials

Conference, Mar. 1977, pp. 117-126. (In A77-25778)

Available as AIAA Paper 77-421. (A77-25791)

323 Sidwell, K.: **Analysis of the Response of Linear Dynamic Systems to Product Random Processes.** J. Sound & Vib., vol. 55, no. 1, Nov. 8, 1977, pp. 55-64.

324 Sobieszczanski-Sobieski, J.; and Bhat, R. B.: **Adaptable Structural Synthesis Using Advanced Analysis and Optimization Coupled by a Computer Operating System.** A Collection of Technical Papers on Structures, AIAA/ASME/ASCE/AHS 20th Structures, Structural Dynamics, and Materials Conference, Apr. 1979, pp. 60-71. (In A79-28251)

Available as AIAA Paper 79-0723. (A79-28256)

325 Stroud, W. J.; Sobieszczanski-Sobieski, J.; Walz, J. E.; and Bush, H. G.: **Computerized Structural Sizing at NASA Langley Research Center.** AIAA Paper 78-1550, Aug. 1978. (A78-46513)

326 Swaim, Robert L.; and Staab, George H.: **Prediction of Elastic-Airplane Lateral Dynamics From Rigid-Body Aerodynamics.** AIAA Paper 77-1125, Aug. 1977. (A77-43158)

327 Tenney, D. R.; and Unnam, J.: **Analytical Prediction of Moisture Absorption in Composites.** J. Aircr., vol. 15, no. 3, Mar. 1978, pp. 148-154.

328 Tompkins, Stephen S.: **Influence of Surface and Environmental Thermal Properties on Moisture in Composites.** Fibre Sci. & Technol., vol. 11, no. 3, May 1978, pp. 189-197.

329 Tseng, Kadin; Puglise, Joseph A.; and Morino, Luigi: **Recent Developments in the Green's Function Method.** AIAA Paper 77-456, Mar. 1977. (A77-28045)

330 Voehringer, Charles A.; and Anderson, David W.: **Manufacturing Methods for Advanced Sandwich Panel Construction.** AFML-TR-77-35, Pt. II, U.S. Air Force, Oct. 1978. (X80-71372)

Available from DTIC as AD B039 029.

331 Vosteen, Louis F.: **Composite Structures for Commercial Transport Aircraft.** NASA paper presented at the Second International Conference on Composite Materials (Toronto, Canada), Apr. 1978. (A78-34901)

332 Waco, David E.: **Mesoscale Wind and Temperature Fields Related to an Occurrence of Moderate Turbulence Measured in the Stratosphere Above Death Valley.** Mon. Weather Rev., vol. 106, no. 6, June 1978, pp. 850-858.

333 Weisart, E. D.; Stacher, G. W.; and Kim, B. W.: **Manufacturing Methods for Superplastic Forming/Diffusion Bonding Process.** AFML-TR-79-4053 (Contract F33615-75-C-5058), May 1979. (X80-73006)

Available from DTIC as AD B041 873.

334 Weiss, S. J.; Tseng, K.; and Morino, L.: **State-Space Formulations for Flutter Analysis.** AIAA Paper 77-117, Jan. 1977. (A77-22230)

335 Whitcomb, J. D.: **Thermographic Measurement of Fatigue Damage.** Composite Materials: Testing and Design (Fifth Conference), S. W. Tsai, ed., ASTM Spec. Tech. Publ. 674, 1978, pp. 502-516. (In A80-21126)

336 *Wiggins, John H.: **Sound and Vibration Measurements for Concorde Supersonic Transport and Subsonic Jet Aircraft.** DOT-TST-75-21, U.S. Dep. Transp., July 31, 1974. (N75-24436)

Available from NTIS as PB 238 748.

*Omitted in previous bibliography.

337 Zelahy, J. W.: **Manufacturing Methods for Shrouded Blade & Vane Fabrication.** AFML-TR-79-4061, Vol. 1, U.S. Air Force, June 15, 1979. (X80-72639)

Available from DTIC as AD B041 630.

NASA Formal Reports

338 Barger, Raymond L.: **Sonic-Boom Wave-Front Shapes and Curvatures Associated With Maneuvering Flight.** NASA TP-1611, 1979. (N80-14045)

Sonic-boom wave shapes and caustic lines generated by an airplane performaing a general maneuver are studied. The equations are programmed for graphical output as a perspective view of the wave shape. This quasi-three-dimensional presentation provides a qualitative insight into the effects of the maneuver on the wave shape and the caustic locations. For the special case of planar maneuvers, the principal curvatures of the wave front are derived. These curvatures are needed to calculate the sound field in the vicinity of a caustic. The results of the analysis are applicable not only to sonic-boom studies but also to the calculation of noise generated by a supersonic rotor or propeller blade tip.

339 *Bauer, Carol A.; Mackall, Karen G.; Stoll, Frederick; and Tremback, Jeffrey W.: **Comparison of Flight and Wind Tunnel Model Instantaneous Distortion Data From a Mixed-Compression Inlet.** YF-12 Experiments Symposium – Volume 3, NASA CP-2054, 1978, pp. 295-375. (In X79-72834)

Comparisons were made between flight and wind tunnel distortion data to determine whether values of instantaneous distortion obtained from wind tunnel models could be used to predict instantaneous distortion values present in flight. In this study data from a mixed-compression inlet on a YF-12C airplane were compared with data obtained from both a full-scale and a one-third-scale wind tunnel model of the same inlet, all operating at nearly identical test conditions for two supersonic Mach numbers. Steady-state and instantaneous values of radial, circumferential, and maximum-minus-minimum distortion descriptors were used for the analysis. Strouhal number scaling techniques were used so that the properties of the fluctuating components of the descriptors, such as the mean value, the standard deviation, an inlet turbulence term, and the maximum value of instantaneous distortion could be compared. A linear relationship existed between the maximum value of instantaneous distortion and the steady-state distortion value.

*Classified.

340 *Brilliant, Howard M.; Bauer, Carol A.; and Davis, Robert A.: **Predicted and Measured Maximum Instantaneous Distortion for Flight and Wind Tunnel Model Data for a Mixed-Compression Inlet.** YF-12 Experiments Symposium – Volume 3, NASA CP-2054, 1978, pp. 377-406. (In X79-72834)

A method was recently developed for estimating probable maximum instantaneous compressor face total pressure distortion. The advantage of this method is that it requires fewer total pressure measurements to be made. In the present study, the same method was applied to the YF-12C mixed-compression inlet using data obtained from YF-12C flight tests and from wind tunnel tests of both full-scale and one-third-scale inlet models. Values estimated by the method investigated were found to be within 20 percent of the measured values for the three sets of data examined.

*Classified.

341 Carlson, Harry W.: **A Modification to Linearized Theory for Prediction of Pressure Loadings on Lifting Surfaces at High Supersonic Mach Numbers and Large Angles of Attack.** NASA TP-1406, 1979. (N79-17806)

A new linearized-theory pressure coefficient formulation was studied. The new formulation is intended to provide more accurate estimates of detailed pressure loadings for improved stability analysis and for analysis of critical structural design conditions. The approach is based on the use of oblique-shock and Prandtl-Meyer expansion relationships for accurate representation of the variation of pressures with surface slopes in two-dimensional flow and linearized theory perturbation velocities for evaluation of local three-dimensional aerodynamic interference effects. The applicability and limitations of the modification to linearized theory are illustrated through comparisons with experimental pressure distributions for delta wings covering a Mach number range from 1.45 to 4.60 and angles of attack from 0 to 25°.

342 Carlson, Harry W.: **Simplified Sonic-Boom Prediction.** NASA TP-1122, 1978. (N78-20078)

Sonic boom overpressures and signature duration may be predicted for the entire affected ground area for a wide variety of supersonic airplane configurations and spacecraft operating at altitudes up to 76 km in level flight or in moderate climbing or descending flight paths. The outlined procedure relies to a great extent on the use of charts to provide generation and propagation factors for use in relatively simple expressions for signature calculation. Computational requirements can be met by hand-held scientific calculators, or even by slide rules. A variety of correlations of predicted and measured sonic-boom data for airplanes and spacecraft serve to demonstrate the applicability of the simplified method.

343 Carlson, Harry W.; and Mack, Robert J.: **Estimation of Leading-Edge Thrust for Supersonic Wings of Arbitrary Planform.** NASA TP-1270, 1978. (N78-33051)

A numerical method for the estimation of leading edge thrust for supersonic wings of arbitrary planform was developed and was programmed as an extension to an existing high speed digital computer method for prediction of wing pressure distributions. The accuracy of the method was assessed by comparison with linearized theory results for a series of flat delta wings. Application of the method to wings of arbitrary planform, both flat and cambered, is illustrated in several examples.

344 Carlson, Harry W.; and Mack, Robert J.: **A Study of the Sonic-Boom Characteristics of a Blunt Body at a Mach Number of 4.14.** NASA TP-1015, 1977. (N77-32072)

An experimental and theoretical study has shown that the applicability of far-field sonic-boom theory previously demonstrated for more slender shapes may now be extended to bodies with ratios of diameter to lengths as great as 2 and to Mach numbers at least as high as 4.14. This finding is of special significance in view of the limitations to the use of existing methods for the extrapolation of close-in experimental data.

345 Carlson, Harry W.; Mack, Robert J.; and Barger, Raymond L.: **Estimation of Attainable Leading-Edge Thrust for Wings at Subsonic and Supersonic Speeds.** NASA TP-1500, 1979. (N80-10105)

A study has been made of the factors which place limits on the theoretical leading-edge thrust, and an empirical method has been developed for the estimation of attainable thrust. The method is based on the use of theoretical airfoil programs to define thrust dependence on local geometric characteristics, and the examination of experimental two-dimensional airfoil data to define limitations imposed by local Mach numbers and Reynolds numbers. The method was demonstrated by comparisons of theoretical and experimental aerodynamic characteristics for a series of wing-body configurations.

346 Coe, Paul L., Jr.; and Huffman, Jarrett K.: **Influence of Optimized Leading-Edge Deflection and Geometric Anhedral on the Low-Speed Aerodynamic Characteristics of a Low-Aspect-Ratio Highly Swept Arrow-Wing Configuration.** NASA TM-80083, 1979. (N79-207095)

An investigation has been conducted in the Langley 7- by 10-Foot Tunnel to determine the influence of an optimized leading-edge deflection on the low-speed aerodynamic performance of a configuration with a low-aspect-ratio, highly swept wing. For the particular configuration studied, levels of leading-edge suction on the order of 90 percent were achieved. The results of tests conducted to determine the sensitivity of C_{ℓ_β} to geometric anhedral indicate values of $\partial C_{\ell_\beta}/\partial \Gamma$ which are in reasonable agreement with estimates provided by simple vortex-lattice theories.

347 Coe, Paul L., Jr.; Smith, Paul M.; and Parlett, Lysle P.: **Low-Speed Wind Tunnel Investigation of an Advanced Supersonic Cruise Arrow-Wing Configuration.** NASA TM-74043, 1977. (N77-29096)

A preliminary assessment of possible means for improving the low-speed aerodynamic characteristics of advanced supersonic cruise arrow wing configurations and to extend the existing data base of such configurations has been made. Principal configuration variables included wing leading- and trailing-edge flap deflection, fuselage nose strakes, and engine exhaust nozzle deflection. Results showed that deflecting the wing leading-edge apex flaps downward provided improved longitudinal stability but resulted in reduced directional stability. The model exhibited relatively low values of directional stability over the operational angle of attack range and experienced large asymmetric yawing moments at high angles of attack. The use of nose strakes was found to be effective in increasing the directional stability and eliminating the asymmetric yawing moment.

348 Coe, Paul L., Jr.; Thomas, James L.; Huffman, Jarrett K.; Weston, Robert P.; Schoonover, Ward E., Jr.; and Gentry, Garl L., Jr.: **Overview of the Langley Subsonic Research Effort on SCR Configurations.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 13-33. (In X80-72343)

The present paper summarizes recent advances achieved by the NASA Langley Research Center in the subsonic aerodynamics of highly swept-wing designs. The conceptual designs are representative of future generation commercial and military vehicles and incorporate wing sweeps on the order of 70° to 80°. Unfortunately, owing to the high wing sweeps, such configurations exhibit deficiencies in the area of subsonic performance, stability, and control. The most significant of the advances has been the development of leading-edge deflection concepts which effectively reduce leading-edge flow separation. The improved flow attachment results in substantial improvements in low-speed performance, significant delay of longitudinal pitch-up, increased trailing-edge flap effectiveness, and increased lateral-control capability. The paper also considers various additional theoretical and/or experimental studies which, in conjunction with continued leading-edge deflection studies, form the basis for Langley's future subsonic research effort.

349 Coe, Paul L., Jr.; and Weston, Robert P.: **Effects of Wing Leading-Edge Deflection on Low-Speed Aerodynamic Characteristics of a Low-Aspect-Ratio Highly Swept Arrow-Wing Configuration.** NASA TP-1434, 1979. (N79-26020)

An experimental investigation has been conducted to determine the effects of wing leading-edge deflection on the low-speed aerodynamic characteristics of a low-aspect-ratio highly swept arrow-wing configuration. Static force tests were conducted in the Langley V/STOL Tunnel at a Reynolds number of about 2.0×10^6 for an angle-of-attack range from about -10° to 17° and angles of sideslip of 0 and ±5°. Limited flow visualization studies were also conducted.

350 Decker, John P.; and Jacobs, Peter F.: **Stability and Performance Characteristics of a Fixed Arrow Wing Supersonic Transport Configuration (SCAT 15F-9898) at Mach Numbers From 0.60 to 1.20.** NASA TM-78726, 1978. (N78-30087)

Tests on a 0.015-scale model of a supersonic transport were conducted at Mach numbers from 0.60 to 1.20. Tests of the complete model with three wing planforms, two different leading-edge radii, and various combinations of component parts, including both leading- and trailing-edge flaps, were made over an angle-of-attack range from about -6° to 13° and at sideslip angles of 0° and 2°.

351 Dollyhigh, Samuel M.: **Experimental Aerodynamic Characteristics at Mach Numbers From 0.60 to 2.70 of Two Supersonic Cruise Fighter Configurations.** NASA TM-78764, 1979. (N79-20062)

Two 0.085-scale full-span wind-tunnel models of a Mach 1.60 design supercruiser configuration were tested at Mach numbers from 0.60 to 2.70. One model incorporated a varying dihedral (swept-up) wing to obtain the desired lateral-directional characteristics; the other incorporated more conventional twin vertical tails. The data from the wind-tunnel tests are presented without analysis.

352 Dollyhigh, Samuel M.: **Theoretical Evaluation of High-Speed Aerodynamics for Arrow-Wing Configurations.** NASA TP-1358, 1979. (N79-14023)

The use of the theoretical methods to calculate the high-speed aerodynamic characteristics of arrow-wing supersonic cruise configurations was studied. Included are correlations of theoretical predictions with wind-tunnel data at Mach numbers from 0.8 to 2.7, examples of the use of theoretical methods to extrapolate the wind-tunnel data to full-scale flight conditions, and presentation of a typical supersonic data package for an advanced supersonic transport application. A brief description of the methods and their application is given.

353 Fisher, David F.: **Boundary Layer, Skin Friction, and Boattail Pressure Measurements From the YF-12 Airplane at Mach Numbers up to 3.** YF-12 Experiments Symposium, Volume 1, NASA CP-2054, 1978, pp. 227-258. (In N78-32055)

In-flight measurements of boundary layer and skin friction data were made on YF-12 airplanes for Mach numbers between 2.0 and 3.0. Boattail pressures were also obtained for Mach numbers between 0.7 and 3.0 with Reynolds numbers up to four hundred million. Boundary layer data measured along the lower fuselage centerline indicate that local displacement and momentum thicknesses can be much larger than predicted. Skin friction coefficients measured at two of five lower fuselage stations were significantly less than predicted by flat plate theory. The presence of large differences between measured boattail pressure drag and values calculated by a potential flow solution indicates the presence of vortex effects on the upper boattail surface. At both subsonic and supersonic speeds, pressure drag on the longer of two boattail configurations was equal to or less than the pressure drag on the shorter configuration. At subsonic and transonic speeds, the difference in the drag coefficient was on the order of 0.0008 to 0.0010. In the supersonic cruise range, the difference in the drag coefficient was on the order of 0.002. Boattail drag coefficients are based on wing reference area.

354 Goebel, T. P.; Bonner, E.; and Robinson, D. A.: **A Study of Wing Body Blending for an Advanced Supersonic Transport.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 149-169. (In X80-72343)

Increases in supersonic cruise lift-drag ratio were sought at Mach numbers of 2.2 and 2.7 using wing-body planform and thickness blending. Constrained twist and camber optimization was performed in the presence of nacelles. Wing and fuselage thickness distributions were optimized for either minimum volume wave drag or minimum total pressure wave drag. The lift-drag ratios for zero leading edge suction were determined for three wing planforms. The magnitude of the effect of leading edge suction on attainable lift-drag ratio was defined on one planform and an estimation of available leading edge suction was made.

355 Heyson, Harry H.: **TESTPLT – Interactive Computer Procedure for Wind-Tunnel-Data Management, Retrieval, Comparison, and Plotting.** NASA TM-78663, 1978. (N78-20144)

A method of maintaining, retrieving, comparing, and plotting wind-tunnel data by means of an interactive remote computer terminal is described. The software associated with the method consists of two procedure files, three computer programs, and a submittal file, all of which are discussed. The procedure was based on maintaining the basic wind-tunnel data files in the Langley standard interface tape (SIFT) format. The SIFT format was not part of the present development. Those features of the format essential to the present use were described. The entire method was illustrated by sample executions from a remote terminal.

356 Heyson, Harry H.; Riebe, Gregory D.; and Fulton, Cynthia L.: **Theoretical Parametric Study of the Relative Advantages of Winglets and Wing-Tip Extensions.** NASA TP-1020, 1977. (N77-33112)

It was found that for identical increases in bending moment, a winglet provides a greater gain in induced efficiency than a tip extension. Winglet toe-in angle allows design trades between efficiency and root moment. A winglet showed the greatest benefit when the wing loads were heavy near the tip. Washout diminished the benefit of either tip modification, and the gain in induced efficiency became a function of lift coefficient; heavy wing loadings obtained the greatest benefit from a winglet, and low speed performance was enhanced even more than cruise performance. Both induced efficiency and bending moment increased with winglet length and outward cant. The benefit of a winglet relative to a tip extension was greatest for a nearly vertical winglet. Root bending moment was proportional to the minimum weight of bending material required in the wing; it is a valid index of the impact of tip modifications on a new wing design.

357 Johnson, Vicki S.; and Coe, Paul L., Jr.: **Effect of Outboard Vertical-Fin Position and Orientation on the Low-Speed Aerodynamic Performance of Highly Swept Wings.** NASA TM-80142, 1979. (N79-32158)

A theoretical study has been conducted to determine the potential low-speed performance improvements which can be achieved by altering the position and orientation of the outboard vertical fins of low-aspect-ratio highly swept wings. As expected, the results of the study show that the magnitude of the performance improvements is solely a function of the span-load distribution. Both vertical-fin chordwise position and toe angle provided effective means for adjusting the overall span-load distribution.

358 Kulfan, Robert M.: **Prediction of Nacelle Aerodynamic Interference Effects at Low Supersonic Mach Numbers.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 171-203. (In X80-72343)

A limited study is currently underway to assess the accuracy of analytical predictions of nacelle aerodynamic interference effects at low supersonic speeds by means of test versus theory comparisons. This paper presents a status report and also illustrates effects of nacelle location, nacelle spillage, angle of attack, and Mach number on the aerodynamic interference. The results indicate that the methods can satisfactorily predict lift, drag, pitching moment, and pressure distributions of installed engine nacelles at low supersonic Mach numbers with mass flow ratios from 0.7 to 1.0 for configurations typical of efficient supersonic cruise airplanes.

359 Lockwood, Vernard E.: **Effect of Leading-Edge Contour and Vertical-Tail Configuration on the Low-Speed Stability Characteristics of a Supersonic Transport Model Having a Highly-Swept Arrow Wing.** NASA TM-78683, 1978. (N78-21051)

A low-speed investigation was made on a highly swept arrow-wing model to determine the effect of wing leading-edge contour and vertical-tail configuration on the aerodynamic characteristics in pitch and sideslip. The investigation was made with the trailing-edge flaps deflected over a range of angle of attack from 8° to 32°. The tests were made at a Mach number of 0.12, which corresponds to a Reynolds number of about 3×10^6 based on the wing reference chord.

360 Mack, Robert J.; and Darden, Christine M.: **Wind-Tunnel Investigation of the Validity of a Sonic-Boom-Minimization Concept.** NASA TP-1421, 1979. (N80-10102)

A wind-tunnel investigation was conducted to determine the validity of a sonic-boom-minimization theory. Five models were tested at design Mach numbers of 1.5 and 2.7. The pressure signatures generated by the low-boom models had significantly lower overpressure levels than those produced by the reference models. Boundary-layer effects were found to be sizable on the low-boom models, and when viscous corrections were included in the analysis, improved agreement between the predicted and the measured signatures was noted. It was concluded that the minimization method was definitely valid at Mach 1.5 and was probably valid at Mach 2.7.

361 Manro, Marjorie E.; Bobbitt, Percy J.; and Kulfan, Robert M.: **The Prediction of Pressure Distributions on an Arrow-Wing Configuration Including the Effect of Camber, Twist, and a Wing Fin.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 59-115. (In X80-72343)

Wind-tunnel tests of an arrow-wing body configuration consisting of flat, twisted, and cambered-twisted wings have been conducted at Mach numbers from 0.40 to 2.50 to provide an experimental data base for comparison with theoretical methods. A variety of leading- and trailing-edge control-surface deflections were included in these tests, and in addition, the cambered-twisted wing was tested with an outboard vertical fin to determine its effect on wing and control-surface loads. Theory-experiment comparisons of detailed pressure distributions have been made using current state-of-the-art attached-flow methods, as well as newly developed attached- and separated-flow methods. The purpose of these comparisons was to delineate conditions under which these theories can provide accurate basic and incremental aeroelastic loads predictions. Special emphasis is given to a new procedure developed by Robert Kulfan which shows promise of being able to predict the onset of a leading-edge vortex on thick and/or warped wings. Theory-experiment comparisons were adequate at small angle of attack, cruise conditions.

362 McLemore, H. Clyde; and Parlett, Lysle P.: **Low-Speed Wind-Tunnel Tests of 1/10-Scale Model of a Blended-Arrow Supersonic Cruise Aircraft.** NASA TN D-8410, 1977. (N77-26069)

Low-speed static force tests have been conducted in a full-scale tunnel to determine the low-speed aerodynamic characteristics of a 1/10-scale model of a blended-arrow supersonic cruise aircraft. A clean configuration and a high lift configuration with several combinations of leading- and trailing-edge flaps to provide improved lift and longitudinal stability in the landing and takeoff modes were used. The tests were made at angles of attack from about -6° to 30°, sideslip angles from -5° to 10°, and Reynolds numbers from 6.78×10^6 to 13.85×10^6 corresponding to test velocities of 41 to 85 knots.

363 McLemore, H. Clyde; Parlett, Lysle P.; and Sewall, William G.: **Low-Speed Wind-Tunnel Tests of 1/9-Scale Model of a Variable-Sweep Supersonic Cruise Aircraft.** NASA TN D-8380, 1977. (N77-26070)

Tests were conducted in the Langley Full-Scale Tunnel to determine the aerodynamic characteristics at low subsonic speeds of a 1/9-scale model of a variable-sweep supersonic cruise aircraft. The model configurations investigated were the basic unflapped arrangement, a take-off flap arrangement, and a landing flap arrangement with several strake leading-edge flow control devices. The tests were conducted at angles of attack from about -5 to 36° and sideslip angles from -5 to 10°.

364 Morris, Odell A.; Fuller, Dennis E.; and Watson, Carolyn B.: **Aerodynamic Characteristics of a Fixed Arrow-Wing Supersonic Cruise Aircraft at Mach Numbers of 2.30, 2.70, and 2.95.** NASA TM-78706, 1978. (N78-32050)

Tests were conducted in the Langley Unitary Plan Wind Tunnel at Mach numbers of 2.30, 2.70, and 2.95 to determine the performance, static stability, and control characteristics of a model of a fixed-wing supersonic cruise aircraft with a design Mach number of 2.70 (SCAT 15-F-9898). The configuration had a 74° swept warped wing with a reflexed trailing edge and four engine nacelles mounted below the reflexed portion of the wing. A number of variations in the basic configuration were investigated; they included the effect of wing leading edge radius, the effect of various model components, and the effect of model control deflections.

365 Powers, Sheryll Goecke: **Flight-Measured Pressure Characteristics of Aft-Facing Steps in Thick Boundary Layer Flow for Transonic and Supersonic Mach Numbers.** YF-12 Experiments Symposium — Volume 1, NASA CP-2054, 1978, pp. 201-226. (In N78-32055)

Aft-facing step base pressure flight data were obtained for three step heights for nominal transonic Mach numbers of 0.80, 0.90, and 0.95 and for supersonic Mach numbers of 2.2, 2.5, and 2.8 with a Reynolds number based on the fuselage length ahead of the step of about 10^8. Surface static pressures were measured ahead of the step, behind the step, and on the step face (base), and a boundary layer rake was used to obtain boundary layer reference conditions. A comparison of the data from the present and previous experiments shows the same trend of increasing base pressure ratio (decreasing drag) with increasing values of momentum thickness to step height ratios. However, the absolute level of these data does not always agree at the supersonic Mach numbers. For momentum thickness to height ratios near 1.0, the differences in the base pressure ratios appear to be primarily a function of Reynolds number based on the momentum thickness. Thus, for Mach numbers above 2, the data analyzed show that the base pressure ratio decreased (drag increases) as Reynolds number based on momentum thickness increases for a given momentum thickness and step height.

366 Preisser, John S.: **Results From an Exploratory Study of Airframe Noise on a Small-Scale Model of a Supersonic Transport Concept.** NASA TM X-74021, 1977. (N77-21090)

An exploratory study of airframe noise on a small-scale model of a supersonic transport concept was made. The model was a 0.015-scale version without landing gear of Langley's advanced supersonic technology configuration concept, AST-110. Noise measurements were made at positions corresponding to directly beneath the model and at the 30° sideline, for both cruise and approach flap configurations, and at velocities up to 34 m/s. In general, results showed the cruise noise to be about 3 dB above the background flow noise and the approach noise to be about 11 dB above. Overall sound pressure levels and spectral shapes agreed with state of the art predictive techniques.

367 *Presley, L.; Kutler, P.; and Sorenson, R.: **Predicted and Measured Flow Fields Upstream of the YF-12 Inlet and Calculation Procedure for Inlet Internal Flow Solutions.** YF-12 Experiments Symposium — Volume 3, NASA CP-2054, 1978, pp. 487-507. (In X79-72834)

Flow field solutions have been obtained for the YF-12 forebody at various Mach numbers and angles of attack. These results are compared to wind tunnel data in the plane of the cowl lip. Good qualitative agreement between the data and the computational results were obtained. Output of the forebody computational code was used to define the upstream flow conditions for a subsequent inlet internal flow solution. The inlet flow solutions were obtained using a three-dimensional shock-capturing technique.

*Classified.

368 Quinn, Robert D.; and Gong, Leslie: **In-Flight Compressible Turbulent Boundary Layer Measurements on a Hollow Cylinder at a Mach**

Number of 3.0. YF-12 Experiments Symposium – Volume 1, NASA CP-2054, 1978, pp. 259-286. (In N78-32055)

Skin temperatures, shearing forces, surface static pressures, boundary layer pitot pressures, and total temperatures were measured on a hollow cylinder 3.04 meters long and 0.437 meter in diameter mounted beneath the fuselage of the YF-12A airplane. The data were obtained at a nominal free stream Mach number of 3.0 and at ratios of wall to recovery temperature of 0.66 to 0.91. The free stream Reynolds number had a minimal value of 4.2×10^6 per meter. Heat transfer coefficients and skin friction coefficients were derived from skin temperature time histories and shear force measurements, respectively. Boundary layer velocity profiles were derived from pitot pressure measurements, and a Reynolds analogy factor of 1.11 was obtained from the measured heat transfer and skin friction data. The skin friction coefficients predicted by the theory of Van Driest were in excellent agreement with the measurements. Theoretical heat transfer coefficients, in the form of Stanton numbers calculated by using a modified Reynolds analogy between skin friction and heat transfer, were compared with measured values. The measured velocity profiles were compared to Cole's incompressible law-of-the-wall profile.

369 Rao, Dhanvada M.: **Exploratory Subsonic Investigation of Vortex-Flap Concept on Arrow Wing Configuration.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 117-129. (In X80-72343)

The drag-reduction potential of a vortex-flap concept, utilizing the thrust contribution of separation vortices maintained over leading-edge flap surfaces, has been explored in subsonic wind tunnel tests on a highly swept arrow wing configuration. Several flap geometries were tested in comparison with a previous study on the same model with leading edges drooped for attached flow. The most promising vortex-flap arrangements produced drag reductions comparable with leading-edge droop over a range of lift coefficients from 0.3 to 0.6 (untrimmed) and also indicated beneficial effects on the longitudinal and lateral static stability characteristics.

370 *Redin, Paul C.: **A Performance Model of the YF-12C Airplane.** YF-12 Experiments Symposium – Volume 3, NASA CP-2054, 1978, pp. 509-534. (In X79-72834)

A performance modeling technique previously developed for an F-104G airplane with a fixed-geometry inlet was modified and applied to a YF-12C airplane with a variable-geometry inlet. Flight test data from level accelerations, climbing accelerations, and constant-Mach-number climbs flown at maximum afterburning power were used to develop and validate the model. After the propulsion and drag data were adjusted, the model-predicted performance data fell to within 6% or less of the measured flight values.

*Classified.

371 Rhyne, Richard H.: **Accuracy of Aircraft Velocities Obtained From Inertial Navigation Systems for Application to Airborne Wind Measurements.** NASA TM-81826, 1980.

An experimental assessment was made of two commercially available inertial navigation systems with regard to their inertial-velocity measuring capability for use in wind, wind shear, and long-wavelength atmospheric turbulence research. The assessment was based on 52 sets of postflight measurements of velocity (error) during a "Schuler cycle" (84 minutes) while the inertial navigation system (INS) was still operating but the airplane was motionless. Four INS units of one type and two units of another were tested over a period of 2 years after routine research flights similar to airline-type operations of from 1 to 6 hours duration. The maximum postflight errors found for the 52 cases had a root-mean-square value of 2.82 m/s with little or no correlation of error magnitude with flight duration in the 1- to 6-hour range.

372 Robins, A. Warner; Carlson, Harry W.; and Mack, Robert J.: **Supersonic Wings With Significant Leading-Edge Thrust at Cruise.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 229-246. (In X80-72343)

Experimental-theoretical correlations are presented which show that significant levels of leading-edge thrust are possible at supersonic speeds for certain planforms which match the theoretical thrust-distribution potential with the supporting airfoil geometry. The new analytical process employed provides not only the level of leading-edge thrust attainable but also the spanwise distribution and/or that component of full *theoretical thrust which acts as vortex lift. Significantly improved aerodynamic performance in the moderate supersonic speed regime is indicated.*

Available as NASA TP-1632, 1980. (N80-21279)

373 Roensch, R. L.; Felix, J. E.; Welge, H. R.; Yip, L. P.; and Parlett, L. P.: **Results of a Low-Speed Wind Tunnel Test of the MDC 2.2M Supersonic Cruise Aircraft Configuration.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 35-57. (In X80-72343)

Results of a low-speed test conducted in the Langley Full-Scale Tunnel using an advanced supersonic cruise vehicle configuration are presented. These tests were conducted using a 10-percent scale model of a configuration developed by McDonnell Douglas that had demonstrated high aerodynamic performance at Mach 2.2 during a previous test program. The low-speed model has leading- and trailing-edge flaps designed to improve low-speed lift-to-drag ratios at high lift and includes devices for longitudinal and lateral-directional control. The results obtained during the low-speed test program have shown that full-span leading-edge flaps are required for maximum performance. The amount of deflection of the leading-edge flap must increase with C_L to obtain the maximum benefit. Over 80 percent of full leading-edge suction was obtained up to lift-off C_L's of 0.65.

374 Roensch, R. L.; and Page, G. S.: **Analytic Development of an Improved Supersonic Cruise Aircraft Based on Wind Tunnel Data.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 205-227. (In X80-72343)

Data obtained from the MDC/NASA cooperative wind tunnel program were used to develop empirical corrections to theory. These methods were then used to develop a Mach 2.2 supersonic cruise aircraft configuration with a cruise trimmed maximum L/D of 10.2. The empirical corrections to the theory are reviewed, and the configuration alternatives examined in the development of the configuration are presented. The benefits of designing for optimum trimmed performance, including the effects of the nacelles, are discussed.

375 Runyan, L. James; Middleton, Wilbur, D.; and Paulson, John A.: **Wind Tunnel Test Results of a New Leading Edge Flap Design for Highly Swept Wings – A Vortex Flap.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 131-147. (In X80-72343)

A new leading edge flap design for highly swept wings, called a vortex flap, has been tested on an arrow wing model in a low speed wind tunnel. A vortex flap differs from a conventional plain flap in that it has a leading edge tab which is counterdeflected from the main portion of the flap. This results in intentional separation at the flap leading edge, causing a vortex to form and lie on the flap. By "trapping" this vortex, the vortex flap can result in significantly improved wing flow characteristics relative to conventional flaps at moderate to high angles of attack, as demonstrated by the flow visualization results of this test.

376 Shivers, James P.; McLemore, H. Clyde; and Coe, Paul L., Jr.: **Low-Speed Wind Tunnel Investigation of a Large-Scale Advanced Arrow Wing Supersonic Transport Configuration With Engines Mounted Above the Wing for Upper-Surface Blowing.** NASA TM X-72761, 1975. (N77-28109)

The Langley Full-Scale Tunnel was used to investigate the low-speed stability and control of an advanced arrow wing supersonic transport with engines mounted above the wing for upper-surface blowing. Tests were made over an angle of attack range of -10° to 32°, slideslip angles of ±5°, and a Reynolds number ranging from 3.53 to 7.33 × 10^6 (referenced to mean aerodynamic chord of the wing). Configuration variables included trailing-edge flap deflection, engine jet nozzle angle, engine thrust coefficient, engine out operation, and asymmetrical trailing-edge boundary-layer control for providing roll trim. Downwash measurements at the tail were obtained for different thrust coefficients, tail heights, and at two fuselage stations.

377 Shrout, Barrett L.; Corlett, William A.; and Collins, Ida K.: **Surface Pressure Data for a Supersonic-Cruise Airplane Configuration at Mach Numbers of 2.30, 2.96, and 3.30.** NASA TM-80061, 1979. (N79-22051)

The tabulated results of surface pressure tests conducted on the wing and fuselage of an airplane model in the Langley Unitary Plan Wind Tunnel are presented without analysis. The model tested was that of a supersonic-cruise airplane with a highly swept arrow-wing planform, two engine nacelles mounted beneath the wing, and outboard vertical tails. Data were obtained at Mach numbers of 2.30, 2.96, and 3.30 for angles of attack from -4^{o} to 12^{o}. The Reynolds number for these tests was 6.56 $\times 10^6$ per meter (2.0 $\times 10^6$ per foot).

378 Shrout, Barrett L.; and Fournier, Roger H.: **Aerodynamic Characteristics of a Supersonic Cruise Airplane Configuration at Mach Numbers of 2.30, 2.96, and 3.30.** NASA TM-78792, 1979. (N79-14025)

An investigation was made in the Langley Unitary Plan Wind Tunnel at Mach numbers of 2.30, 2.96, and 3.30 to determine the static longitudinal and lateral aerodynamic characteristics of a model of a supersonic cruise airplane. The configuration, with a design Mach number of 3.0, has a highly swept arrow wing with tip panels of lesser sweep, a fuselage chine, outboard vertical tails, and outboard engines mounted in nacelles beneath the wing. For wind-tunnel test conditions, a trimmed value above 6.0 of the maximum lift-drag ratio was obtained at the design Mach number. The configuration was statically stable, both longitudinally and laterally. Data are presented for variations of vertical-tail roll-out and toe-in and for various combinations of components. Some roll-control data are shown as are data for the various sand grit sizes used in fixing the boundary-layer transition location.

379 Shrout, Barrett L.; and Hayes, Clyde: **Effect of a Simulated Engine Jet Blowing Above an Arrow Wing at Mach 2.0.** NASA TP-1050, 1977. (N78-10030)

The effects of a gas jet simulating a turbojet engine exhaust blowing above a cambered and twisted arrow wing were investigated. Tests were conducted in the Langley 4-Foot Supersonic Pressure Tunnel at a Mach number of 2.0. Nozzle pressure ratios from 1 to 64 were tested with both helium and air used as jet gases. The tests were conducted at angles of attack from -2^{o} to 8^{o} at a Reynolds number of 9.84 $\times 10^6$ per meter. Only the forces and moments on the wing were measured. Results of the investigation indicated that the jet blowing over the wing caused reductions in maximum lift-drag ratio of about 4 percent for helium and 6 percent for air at their respective design nozzle pressure ratios, relative to jet-off data. Moderate changes in the longitudinal, vertical, or angular positions of the jet relative to the wing had little effect on the wing aerodynamic characteristics.

380 Staff, Langley Research Center: **Jet Noise and Performance Comparison Study of a Mach 2.55 Supersonic Cruise Aircraft.** NASA TM-80094, 1979. (N79-28982)

Data provided by the manufacturer relating to noise and performance of a Mach 2.55 supersonic cruise concept employing a post-1985 technology level, variable cycle engine were used to identify differences in noise levels and performance between the manufacturer and NASA associated with methodology and ground rules. In addition, economic and noise information is provided consistent with a previous study based on an advanced technology Mach 2.7 configuration. The results indicate that the difference between NASA's and the manufacturer's performance methodology is small. Resizing the aircraft to NASA ground rules also results in small changes in flyover, sideline, and approach noise levels. For the power setting chosen, engine oversizing resulted in no reduction in traded noise. In terms of summated noise level, a 10 EPNdB reduction is realized for an 8 percent increase in total operating costs. This corresponds to an average noise reduction of 3.3 EPNdB at three observer positions.

381 Yip, Long P.; and Parlett, Lysle P.: **Low-Speed Wind-Tunnel Tests of a 1/10-Scale Model of an Advanced Arrow-Wing Supersonic Cruise Configuration Designed for Cruise at Mach 2.2.** NASA TM-80152, 1979. (N80-10135)

An investigation was conducted in the Langley Full-Scale Tunnel to determine the low-speed longitudinal and lateral-directional characteristics of a 1/10-scale model of an advanced arrow-wing supersonic cruise configuration designed for Mach 2.2 cruise. Tests were made at a Reynolds number of 4.19 $\times 10^6$ based on the mean aerodynamic chord, with an angle of attack range from -6^{o} to 23^{o} and sideslip angle range from -15^{o} to 20^{o}. Tests were conducted to determine the effects of segmented leading-edge flaps, slotted trailing-edge flaps, horizontal and vertical tails, and ailerons and spoilers. Extensive pressure data and flow visualization pictures with non-intrusive fluorescent mini-tufts were obtained.

NASA Contractor Reports

382 *Denn, Frederick M.: **PLOTIT – Method of Interactively Plotting Input Data for the VORLAX Computer Program.** NASA CR-158896, 1978. (N78-28830)

Geometric input plotting to the VORLAX computer program by means of an interactive remote terminal is reported. The software consists of a procedure file and two programs. The programs and procedure file are described and a sample execution is presented.

*Vought Corp., contract NAS1-13500.

383 *Ehlers, F. Edwards; and Rubbert, Paul E.: **A Mach Line Panel Method for Computing the Linearized Supersonic Flow Over Planar Wings.** NASA CR-152126, 1978. (N78-27087)

A method is described for solving the linearized supersonic flow over planar wings using panels bounded by two families of Mach lines. Polynomial distributions of source and doublet strength lead to simple, closed form solutions for the aerodynamic influence coefficients, and a nearly triangular matrix yields rapid solutions for the singularity parameters. The source method was found to be accurate and stable both for analysis and design boundary conditions. Similar results were obtained with the doublet method for analysis boundary conditions on the portion of the wing downstream of the supersonic leading edge, but instabilities in the solution occurred for the region containing a portion of the subsonic leading edge. Research on the method was discontinued before this difficulty was resolved.

*Boeing Commercial Airplane Co., contract NAS2-7729.

384 *Johnson, Forrester T.: **A General Panel Method for the Analysis and Design of Arbitrary Configurations in Incompressible Flows.** NASA CR-3079, 1980. (N80-24268)

An advanced method for solving the linear integral equations of incompressible potential flow in three dimensions is presented. Both analysis (Neumann) and design (Dirichlet) boundary conditions are treated in a unified approach to the general flow problem. The method is an influence coefficient scheme which employs source and doublet panels as boundary surfaces. Curved panels possessing singularity strengths, which vary as polynomials are used, and all influence coefficients are derived in closed form. A wide variety of numerical results demonstrating the method are presented.

*Boeing Commercial Airplane Co., contract NAS2-7729.

385 *Jones, William P.; and Appa, Kari: **Unsteady Supersonic Aerodynamic Theory for Interfering Surfaces by the Method of Potential Gradient.** NASA CR-2898, 1977. (N77-33121)

A generalized solution of the hyperbolic wave equation was further developed to relate the velocity components at a field point to the potential gradient distribution in the dependence domain. Singular integrals were evaluated in closed form, with numerical integration methods for more complex but analytic functions. Idealization of the lifting surfaces by trapezoidal elements with two sides parallel to the streamlines is computationally efficient. Streamwise integrals were performed analytically, and spanwise integrals were necessary only on element leading and trailing sides. All integrands vanish on the Mach cone. Pressure distributions on a double delta wing and generalized aerodynamic coefficients for three AGARD planforms were calculated and compared with available results.

*Textron Bell Aerospace Co., contract NAS1-13986.

386 *Kandil, O. A.; Atta, E. H.; and Nayfeh, A. H.: **Three Dimensional Steady and Unsteady Asymmetric Flow Past Wings of Arbitrary Planforms.** NASA CR-145235, 1977. (N77-33102)

The nonlinear discrete vortex method was extended to treat the problem of asymmetric flows past a wing with leading-edge separation, including steady and unsteady flows. The problem was formulated in terms of a body-fixed frame of reference, and the nonlinear discrete vortex method was modified accordingly. Only examples of flows past delta wings are presented. Comparison of these results with experimental results for a delta wing undergoing a steady rolling motion at zero angle of attack demonstrates the superiority of the present method in obtaining highly accurate loads. Numerical results for yawed wings at large angles of attack are also presented. In all cases, total load coefficients, pressure distributions and shapes of the free-vortex sheets are shown.

*Virginia Polytechnic Inst. & State Univ., Grant NGR 47-004-090.

387 *Lovell, W. A.; Price, J. E.; Quartero, C. B.; Turriziani, R. V.; and Washburn, G. F.: **Design of a Large Span-Distributed Load Flying-Wing Cargo Airplane With Laminar Flow Control.** NASA CR-145376, 1978. (N78-30045)

A design study was conducted to add laminar flow control to a previously designed span-distributed load airplane while maintaining constant range and payload. With laminar flow control applied to 100 percent of the wing and vertical tail chords, the empty weight increased by 4.2 percent, the drag decreased by 27.4 percent, the required engine thrust decreased by 14.8 percent, and the fuel consumption decreased by 21.8 percent. When laminar flow control was applied to a lesser extent of the chord (approximately 80 percent), the empty weight increased by 3.4 percent, the drag decreased by 20.0 percent, the required engine thrust decreased by 13.0 percent, and the fuel consumption decreased by 16.2 percent. In both cases the required take-off gross weight of the aircraft was less than the original turbulent aircraft.

*Vought Corp., contract NAS1-13500.

388 *Martin, Glenn L.: **Modification to the WDTVOR and VORTWD Computer Programs for Converting Input Data Between VORLAX and Wave Drag Input Formats.** NASA CR-145360, 1978. (N78-25791)

Computer programs, WDTVOR and VORTWD, were developed to convert input data between wave drag and VORLAX input formats. Both programs were modified to include the capability of converting multisegment fuselage data. The capability of converting VORLAX geometric data to wave drag format without camber as well as with camber was added to the VORTWD program. Listings of the original program, the modifications, and the modified program are included for both programs.

*Vought Corp., contract NAS1-13500.

389 *Martin, Glenn L.: **Paneling Techniques for Use With the VORLAX Computer Program.** NASA CR-145364, 1978. (N78-25054)

A method is presented for determining the geometric input data required by the VORLAX computer program in order to accurately model an aircraft configuration. Techniques are described for modeling each of the major components of a configuration and for joining these individual components into a complete configuration. The effects of trailing vortex filaments and methods of avoiding their intersection with downstream panels are also discussed. The methods presented here are applicable to most conventional aircraft configurations.

*Vought Corp., contract NAS1-13500.

390 *Martin, Glenn L.; and Walkley, Kenneth B.: **Aerodynamic Design and Analysis of the AST-204, -205, and -206 Blended Wing-Fuselage Supersonic Transport Configuration Concepts.** NASA CR-159223, 1980. (N80-20232)

The aerodynamic design and analysis of three blended wing-fuselage supersonic cruise configurations providing four, five, and six abreast seating was conducted using a previously designed supersonic cruise configuration as the baseline. The five abreast configuration was optimized for wave drag at a Mach number of 2.7. The four and six abreast configurations were also optimized at Mach 2.7, but with the added constraint that the majority of their structure be common with the five abreast configuration. Analysis of the three configurations indicated an improvement of 6.0, 7.5, and 7.7 percent in cruise lift-to-drag ratio over the baseline configuration for four, five, and six abreast.

*Kentron International, Inc., contract NAS1-16000.

391 *Miranda, Luis R.; Elliott, Robert D.; and Baker, William M.: **A Generalized Vortex Lattice Method for Subsonic and Supersonic Flow Applications.** NASA CR-2865, 1977. (N78-16002)

If the discrete vortex lattice is considered as an approximation to the surface-distributed vorticity, then the concept of the generalized principal part of an integral yields a residual term to the vorticity-induced velocity field. The proper incorporation of this term to the velocity field generated by the discrete vortex lines renders the present vortex lattice method valid for supersonic flow. Special techniques for simulating nonzero thickness lifting surfaces and fusiform bodies with vortex lattice elements are included. Thickness effects of wing-like components are simulated by a double (biplanar) vortex lattice layer, and fusiform bodies are represented by a vortex grid arranged on a series of concentrical cylindrical surfaces. The analysis of sideslip effects by the subject method is described. Numerical considerations peculiar to the application of these techniques are also discussed. The method has been implemented in a digital computer code. A users' manual is included along with a complete FORTRAN compilation, an executed case, and conversion programs for transforming input for the NASA wave drag program.

*Lockheed-California Co., contract NAS1-12972.

392 *Paulson, J. A.; Boctor, M. L.; Maier, R. E.; Middleton, W. D.; and Vachal, J. D.: **Leading Edge Flap Designs for an Arrow Wing Configuration.** NASA CR-145273, 1978. (X78-10027)

Because of its high supersonic aerodynamic efficiency, the low aspect ratio, highly swept wing configuration was studied extensively for application to supersonic cruise vehicles. An area of concern has involved the low speed characteristics of the configuration because of associated deficiencies in performance, stability, and control. Two leading edge flap configurations were designed for an existing NASA arrow wing model. The objective of the designs was to improve low speed drag and stability, with flaps down, by delaying leading edge separation.

*Boeing Commercial Airplane Co., contract NAS1-13559.

393 *Radkey, R. L.; Welge, H. R.; and Felix, J. E.: **Aerodynamic Characteristics of a Mach 2.2 Advanced Supersonic Cruise Aircraft Configuration at Mach Numbers From 0.5 to 2.4.** NASA CR-145094, 1977. (X77-10013)

Wind tunnel tests were conducted on an advanced supersonic cruise aircraft model. Numerous technology problems associated with the design and analysis of supersonic cruise aircraft were explored to create a Mach 2.2 design information data base. The test addressed the validity of design and analysis methods as applied to arrow wing configurations, problems of wing reflexing to achieve beneficial wing-nacelle interference, and the possibility of using an external compression inlet rather than a mixed compression inlet at Mach 2.2. Configuration longitudinal and lateral-directional aerodynamic characteristics were determined, and pressure (247 ports) were taken simultaneously with the force data. Tuft and schlieren pictures were also taken.

*Douglas Aircraft Co., contract NAS1-13633.

394 *Smith, Paul M.: **Low-Speed Aerodynamic Characteristics From Wind-Tunnel Tests of a Large-Scale Advanced Arrow-Wing Supersonic-Cruise Transport Concept.** NASA CR-145280, 1978. (N78-21053)

Tests have been conducted to extend the existing low speed aerodynamic data base of advanced supersonic-cruise arrow-wing configurations. Principal configuration variables included wing leading-edge flap deflection, wing trailing-edge flap deflection, horizontal tail effectiveness, and fuselage forebody strakes. A limited investigation was also conducted to determine the low speed aerodynamic effects due to slotted trailing-edge flaps. Results of this investigation demonstrate that deflecting the wing leading-edge flaps downward to suppress the wing apex vortices provides improved static longitudinal stability; however, it also results in significantly reduced static directional stability. The use of selected fuselage forebody strakes is found to be effective in increasing the level of positive static directional stability. Drooping the fuselage nose, which is required for low-speed pilot vision, significantly improves the lateral-directional trim characteristics.

*Vought Corp., contract NAS1-13500.

395 *Walkley, K. B.: **A Comparison of the Theoretical Aerodynamic Characteristics of the .015 Scale Douglas Mach 2.2 Advanced Supersonic Cruise Transport Model With Wind Tunnel Data.** NASA CR-158897, 1978. (X80-10001)

This report presents the theoretical aerodynamic characteristics of the .015 scale Douglas AST model at Mach numbers from 0.5 to 2.4 and comparisons of these results with measured wind tunnel data. Methods employed in the analysis included the Lockheed VORLAX program, the Boeing Supersonic Analysis/Design System, and a series of aerodynamic routines developed at the NASA Langley Research Center. Both wing-body and wing-body-nacelle configurations have been analyzed. Subsonically, the VORLAX program has excellent correlation for the lift and pitching moment characteristics and good correlation for the drag-due-to-lift results. The supersonic methods generally predict lift and pitching moments with fair accuracy.

*Vought Corp., contract NAS1-13500.

396 *Walkley, Kenneth B.: **A Procedure for the Determination of the Effect of Fuselage Nose**

Bluntness on the Wave Drag of Supersonic Cruise Aircraft. NASA CR-145306, 1978. (N78-17994)

The incremental wave drag penalty due to nose blunting of a fuselage was investigated using a three-dimensional finite difference scheme. An aircraft typical of current supersonic cruise concepts was considered. Computational problems with the finite difference scheme as the fuselage afterbody closes were addressed. A linear theory method was employed to compute the afterbody aerodynamics, and the theory effectively extends the finite difference scheme to closing afterbodies. Acceptable drag increments for various levels of nose bluntness were demonstrated using this approach.

*Vought Corp., contract NAS1-13500.

Articles, Meeting Papers, and Company Reports

397 Atta, E. H.; Kandil, O. A.; Mook, D. T.; and Nayfeh, A. H.: **Unsteady Aerodynamic Loads on Arbitrary Wings Including Wing-Tip and Leading-Edge Separation.** AIAA Paper 77-156, Jan. 1977. (A77-22238)

398 Dusto, A. R.; Epton, M. A.; and Johnson, F. T.: **Advanced Panel Type Influence Coefficient Methods Applied to Unsteady Three Dimensional Potential Flows.** AIAA Paper 78-229, Jan. 1978. (A78-52630)

399 Ehlers, F. E.; Epton, M. A.; Johnson, F. T.; Magnus, A. E.; and Rubbert, P. E.: **An Improved Higher Order Panel Method for Linearized Supersonic Flow.** AIAA Paper 78-15, Jan. 1978. (A78-52628)

400 Kulfan, R. M.: **Wing Geometry Effects on Leading-Edge Vortices.** AIAA Paper 79-1872, Aug. 1979. (A79-49341)

401 Kulfan, R. M.; and Sigalla, A.: **Real Flow Limitations in Supersonic Airplane Design.** AIAA Paper 78-147, Jan. 1978. (A78-22586)

402 Kutler, P.; Pulliam, T. H.; and Vigneron, Y. C.: **Computation of the Viscous Supersonic Flow Over Symmetrical and Asymmetrical External Axial Corners.** AIAA Paper 78-1135, July 1978. (A78-41839)

403 Lamar, J. E.: **Strake-Wing Analysis and Design.** AIAA Paper 78-1201, July 1978. (A78-41891)

404 Luckring, J. M.: **Theoretical and Experimental Aerodynamics of Strake-Wing Interactions up to High Angles-of-Attack.** AIAA Paper 78-1202, July 1978. (A78-41892)

405 Manro, Marjorie E.; Bobbitt, Percy J.; and Rogers, John T.: **Comparisons of Theoretical and Experimental Pressure Distributions on an Arrow-Wing Configuration at Subsonic, Transonic, and Supersonic Speeds.** Prediction of Aerodynamic Loading, AGARD-CP-204, Feb. 1977, pp. 11-1 – 11-14. (In N77-19990)

406 Pergament, H. S.; and Dash, S. M.: **Prediction of Nearfield Jet Entrainment by an Interactive Mixing/Afterburning Model.** AIAA Paper 78-1189, July 1978. (A73-41882)

407 Vigneron, Y. C.: **Calculation of Supersonic Viscous Flow Over Delta Wings With Sharp Subsonic Leading Edges.** AIAA Paper 78-1137, July 1978. (A78-41841)

SCR STABILITY AND CONTROL

NASA Formal Reports

408 Averett, Ben T.: **Simulator Investigation of Arrow-Wing Low-Speed Handling Qualities.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 285-298. (In X80-72343)

Low-speed handling qualities of arrow wings were investigated with a piloted simulator. Existing aerodynamic data were used from NASA SCAT 15F tunnel tests augmented with new Lockheed low-speed wind-tunnel test data. Two arrow wing planforms were chosen for the simulation effort: a Mach 2.0 design and a Mach 2.7 design. These designs are in the SCAT 15F Mach 2.7 design family, having the same βAR and βcot Λ. Piloted simulation results indicate that both the Mach 2.0 and Mach 2.7 planforms have satisfactory longitudinal flying qualities. However, in the control of bank angle the Mach 2.0 planform demonstrates satisfactory handling qualities while the Mach 2.7 planform is unacceptable. This situation applies for crosswind landings at FAA limits and for lineup in heavy turbulence. The low-speed superiority of the Mach 2 planform with its lower sweep and higher aspect ratio is also shown by its ability to approach at least 8 m/s (15 knots) slower than the Mach 2.7 planform without degradation in handling qualities.

409 *Berry, Donald T.: **A Summary of YF-12 Handling Qualities.** YF-12 Experiments Symposium – Volume 2. NASA CP-2054, 1978, pp. 31-57. (In X79-10157)

Handling quality observations made during the YF-12 flight research program are summarized. Emphasis is placed on characteristics generic to supersonic cruise vehicles, particularly those associated with longitudinal control during high-altitude, supersonic cruise. Low levels of longitudinal short period damping are acceptable to the pilot; however, control of Mach number and altitude can be a problem because of decreased control effectiveness, sluggish propulsion system response, and atmospheric disturbances, accentuated by an unfavorable balance between kinetic and potential energy. It was found that marked improvements could be obtained through the use of better cockpit displays.

*Classified.

410 Chalk, Charles R.: **Flying Qualities Design Criteria Applicable to Supersonic Cruise Aircraft.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 251-267. (In X80-72343)

A comprehensive set of flying quality design criteria has been prepared for use in the NASA Supersonic Cruise Research Program. The framework for stating the design criteria is established and design criteria are included which address specific failures, approach to dangerous flight conditions, flight at high angle of attack, longitudinal and lateral-directional stability and control, the primary flight control system, and secondary flight controls. In this paper, examples are given of lateral-directional design criteria limiting lateral accelerations at the cockpit, time to roll through 30° of bank, and time delay in the pilot's command path. Flight test data from the Concorde certification program are used to substantiate a number of the proposed design criteria.

411 Feather, John B.: **Advanced Supersonic Transport Fixed-Base Simulator Evaluations at Landing Approach.** Supersonic Cruise Research '79 – Part 1, NASA CP-2108, 1980, pp. 269-283. (In X80-72343)

Equations of motion simulating the landing approach of a supersonic cruise vehicle have been programmed and exercised using a fixed-base simulation facility. The objectives were to provide unaugmented and augmented system comparisons and to make refinements as necessary for system performance improvement. The unaugmented longitudinal responses to elevator commands were slow and sluggish, requiring augmentation to increase the speed of the response. In the lateral-directional case, the Dutch roll was highly underdamped and required an augmentation system to increase this damping and provide satisfactory flying qualities. The status of this fixed-base study is that the longitudinal equations, updated with recent wind tunnel data, have been evaluated on the simulator and the system found to be satisfactory. The lateral-axis equations are linearized and have not yet been updated to large excursion capability.

412 Gilyard, Glenn B.; and Burken, John J.: **Development and Flight Test Results of an Autothrottle Control System at Mach 3 Cruise.** NASA TP-1621, 1980.

This report presents flight test results obtained with the original Mach hold autopilot designed for the YF-12C airplane which uses elevator control and a newly developed Mach hold system which uses an autothrottle integrated with a previously developed altitude hold autopilot system. The autothrottle system was flight tested in Mach 3 cruise flight. The results of simulation studies are also presented. The main objective of the autothrottle tests was to demonstrate good speed control at high Mach numbers and high altitudes while simultaneously maintaining control over altitude and good ride qualities. The autothrottle system was designed to control either Mach number or equivalent airspeed. Excellent control of Mach number was obtained with the autothrottle system when combined with altitude hold. Ride qualities were also significantly better than with the conventional Mach hold system.

413 Gilyard, Glenn, B.; and Smith, John W.: **Flight Experience With Altitude Hold and Mach Hold Autopilots on the YF-12 Aircraft at Mach 3.**

YF-12 Experiments Symposium — Volume 1, NASA CP-2054, 1978, pp. 97-119. (In N78-32055)

The altitude hold mode of the YF-12A airplane was modified to include a high-pass-filtered pitch rate feedback along with optimized inner loop altitude rate proportional and integral gains. An autothrottle control system was also developed to control either Mach number or estimated airspeed at the high-speed flight conditions. Flight tests indicate that, with the modified system, significant improvements are obtained in both altitude and speed control, and the combination of altitude and autothrottle hold modes provides the most stable aircraft planform thus far demonstrated at Mach 3 conditions.

414 Gilyard, Glenn B.; and Smith, John W.: **Results From Flight and Simulator Studies of a Mach 3 Cruise Longitudinal Autopilot.** NASA TP-1180, 1978. (N78-21160)

At Mach numbers of approximately 3.0 and altitudes greater than 21 300 meters, the original altitude and Mach hold modes of the YF-12 autopilot produced aircraft excursions that were erratic or divergent, or both. Flight data analysis and simulator studies showed that the sensitivity of the static pressure port to angle of attack had a detrimental effect on the performance of the altitude and Mach hold modes. Good altitude hold performance was obtained when a high-passed pitch rate feedback was added to compensate for angle of attack sensitivity and the altitude error and integral altitude gains were reduced. Good Mach hold performance was obtained when the angle of attack sensitivity was removed; however, the ride quality remained poor.

415 Grantham, William D.; Nguyen, Luat T.; Deal, Perry L.; Neubauer, M. J., Jr.; Smith, Paul M.; and Gregory, Frederick D.: **Ground-Based and In-Flight Simulator Studies at Low-Speed Handling Characteristics of Two Supersonic Cruise Transport Concepts.** NASA TP-1240, 1978. (N78-27111)

Conventional and powered lift concepts for supersonic approach and landing tasks are considered. Results indicated that the transport concepts had unacceptable low-speed handling qualities with no augmentation and that in order to achieve satisfactory handling qualities, considerable augmentation was required. The available roll-control power was acceptable for the powered-lift concept.

416 Grantham, William D.; and Smith, Paul M.: **Development of SCR Aircraft Takeoff and Landing Procedures for Community Noise Abatement and Their Impact on Flight Safety.** Supersonic Cruise Research '79 — Part 1, NASA CP-2108, 1980, pp. 299-333. (X80-72343)

Piloted simulator studies have been conducted to determine takeoff and landing procedures for a supersonic cruise transport concept that result in predicted community noise levels which meet current Federal Aviation Administration (FAA) standards. The results of the study indicate that with the use of advanced procedures, the subject simulated aircraft meets the FAA traded noise levels during takeoff and landing utilizing average flight crew skills. The advanced takeoff procedures developed involved violate three current Federal Aviation Regulations (FAR) noise test conditions. These are (a) thrust cutbacks at altitudes below 214 meters (700 ft), (b) thrust cutback level below those presently allowed, and (c) configuration change, other than raising the landing gear. It was not necessary to violate any FAR noise test conditions during landing approach. It was determined that the advanced procedures developed in this study do not compromise flight safety. Automation of some of the aircraft functions reduced pilot workload, and the development of a simple head-up display to assist in the takeoff flight mode proved to be adequate.

417 Powers, Bruce G.: **Phugoid Characteristics of a YF-12 Airplane With Variable-Geometry Inlets Obtained in Flight Tests at a Mach Number of 2.9.** NASA TP-1107, 1977. (N78-12100)

Flight tests were conducted with the YF-12 airplane to examine the airplane's longitudinal characteristics at a Mach number of approximately 2.9. Phugoid oscillations as well as short period pulses were analyzed with the variable geometry engine inlets in the fixed and the automatic configurations. Stability and control derivatives for the velocity and altitude degrees of freedom and the standard short period derivatives were obtained. Inlet bypass door position was successfully used to represent the total inlet system, and the effect of the inlets on the velocity and altitude derivatives was determined. The phugoid mode of the basic airplane (fixed inlet configuration) had neutral damping, and the height mode was stable. With the addition of the inlets in the automatic configuration, the phugoid mode was slightly divergent and the height mode was divergent with a time to double amplitude of about 114 seconds. The results of the derivative estimation indicated that the change in the height mode characteristics was primarily the result of the change in the longitudinal force derivative with respect to velocity.

418 *Reukauf, Paul J.: **Flight Test Experience With a Digital Airframe/Propulsion Control System on a YF-12 Airplane.** YF-12 Experiments Symposium – Volume 3, NASA CP-2054, 1978, p. 477. (In X79-72834)

A YF-12 airplane with a digital air data system, autopilot system, inlet control system, and autothrottle system was flight tested at Dryden Flight Research Center. Some of the problems which were encountered when converting the analog systems to digital systems are discussed. The problem of integrating the various systems with new control laws for flight-path and performance optimization are also discussed.

*Classified.

419 Rezek, Terrence W.: **Pilot Workload Measurement and Experience on Supersonic Cruise Aircraft.** YF-12 Experiments Symposium – Volume 1, NASA CP-2054, 1978, pp. 121-134. (In N78-32055)

The YF-12 aircraft is considered representative of high workload supersonic cruise aircraft. A study was performed to determine which aircraft parameters and which physiological parameters would be most indicative of crew workload. This study is summarized and the recommendations formed a basis for a continuing study in which variations of the interval between heartbeats is examined as a measure of nonphysical workload. Preliminary results of this work are presented. Current efforts in further defining this physiological measure are outlined.

NASA Contractor Reports

420 *Andrisani, D., II; Daughaday, H.; Dittenhauser, J.; and Rynaski, E.: **The Total In-Flight Simulator (TIFS) Aerodynamics and Systems – Description and Analysis.** NASA CR-158965, [1978]. (N79-14113)

The aerodynamics, control system, instrumentation complement, and recording system of the USAF Total In/Flight Simulator (TIFS) airplane are described. A control system that would allow the ailerons to be operated collectively, as well as differentially, to entrance the ability of the vehicle to perform the dual function of maneuver load control and gust alleviation is emphasized. Mathematical prediction of the rigid body and the flexible equations of longitudinal motion using the level 2.01 FLEXSTAB program are included along with a definition of the vehicle geometry, the mass and stiffness distribution, the calculated mode frequencies and mode shapes, and the resulting aerodynamic equations of motion of the flexible vehicle. A complete description of the control and instrumentation system of the aircraft is presented, including analysis, ground test, and flight data comparisons of the performance and bandwidth of the aerodynamic surface servos.

*Calspan Corp., contract F33615-73-C-3051.

421 *Athans, M.; Baram, Y.; Castanon, D.; Dunn, K. P.; Green, C. S.; Lee, W. H.; Sandell, N. R., Jr.; and Willsky, A. S.: **Investigation of the Multiple Model Adaptive Control (MMAC) Method for Flight Control Systems.** NASA CR-3089, 1979. (N79-23099)

The stochastic adaptive control of the NASA F-8C digital-fly-by-wire aircraft using the Multiple Model Adaptive Control (MMAC) method is presented. The report discusses the selection of the performance criteria for the lateral and the longitudinal dynamics, the design of the Kalman filters for different operating conditions, the identification algorithm associated with the MMAC method, the control system design, and simulation results obtained using the real time simulator of the F-8 aircraft at the NASA Langley Research Center.

*Massachusetts Inst. of Technol., grant NSG-1018.

422 *Chalk, C. R.: **Recommendations for SCR Flying Qualities Design Criteria.** NASA CR-159236, 1980.

The document contains a complete set of flying qualities design criteria applicable to large supersonic cruise aircraft. The design criteria are derived from existing civil and military flying qualities specifications, recent research data, and documented characteristics of operational aircraft. The extensive appendix contains background information and substantiation data for the design criteria.

*Calspan Corp., contract F33615-78-C-3602.

423 *Gordon, C. K.; and Visor, O. E.: **SCAR Arrow-Wing Active Flutter Suppression System.** NASA CR-145147, 1977. (N77-22146)

The potential performance and direct operating cost benefits of an active flutter suppression system (FSS) for the NASA arrow-wing supersonic cruise configuration were determined. A FSS was designed to increase the flutter speed of the baseline airplane 20 percent. A comparison was made of the performance and direct operating cost between the FSS equipped aircraft and a previously defined configuration with structural modifications to provide the same flutter speed. Control system synthesis and evaluation indicated that a FSS could provide the increase in flutter speed without degrading airplane reliability, safety, handling qualities, or ride quality, and without increasing repeated loads or hydraulic and electrical power capacity requirements.

*Boeing Co., contract NAS1-14205.

424 *Matthew, John R.: **Developing, Mechanizing, and Testing of a Digital Active Flutter Suppression System for a Modified B-52 Wind-Tunnel Model.** NASA CR-159155, 1980. (N80-19566)

A study was conducted to develop and mechanize a digital flutter suppression system for a significantly modified version of the 1/30-scale B-52E aeroelastic wind tunnel model. A model configuration was identified that produced symmetric and antisymmetric flutter modes that occur at 2873 N/m^2 (60 psf) dynamic pressure with violent onset. The flutter suppression system, using one trailing edge control surface and two accelerometers on each wing, extended the flutter dynamic pressure of the model beyond the design limit of 4788 N/m^2 (100 psf). The hardware and software required to implement the flutter suppression system were designed and mechanized using digital computers in a fail-operate configuration. The model equipped with the system was tested in the Transonic Dynamics Tunnel at NASA Langley Research Center.

*Boeing Military Airplane Co., contract NAS1-14031.

425 *Roberts, Philip A.; Swaim, Robert L.; Schmidt, David K.; and Hinsdale, Andrew J.: **Effects of Control Laws and Relaxed Static Stability on Vertical Ride Quality of Flexible Aircraft.** NASA CR-143843, 1977. (N77-23127)

State variable techniques are utilized to generate the root-mean-square vertical load factors for the B-52H and B-1 bombers at low level, mission critical, cruise conditions. A ride quality index is proposed to provide meaningful comparisons between different controls or conditions. Ride quality is shown to be relatively invariant under various popular control laws. Handling quality variations are shown to be major contributors to ride quality variations on both vehicles. Relaxed static stability is artificially implemented on the study vehicles to investigate its effects on ride quality. The B-52H ride quality is generally degraded when handling characteristics are automatically restored by a feedback control to the original values from relaxed stability conditions. The B-1 airplane shows little ride quality sensitivity to the same analysis due to the small rigid body contribution to load factors at the flight condition investigated.

*Purdue Univ., Grant NSG-4003.

426 *Rynaski, E. G.; Andrisani, D., II; and Weingarten, N.: **Active Control for the Total-In-Flight Simulator (ACTIFS).** NASA CR-3118, 1979. (N79-23978)

This report addresses the problem of identification of the aeroelastic equations of motion of an airplane and definitions of criteria and design principles for gust alleviation, maneuver load control, and structural mode suppression of a large elastic airplane. A procedure has been developed that is used to systematically update the mathematical model of the aeroelastic behavior of an airplane. A mathematical model that was originally obtained by analytical or theoretical methods is made amenable to piecemeal acceptance of parameters estimated from the data taken during flight tests. Linear optimal control theory was used. Control laws for the proper pole placement of two rigid body and five elastic modes were developed. A conceptual design example of a simplified observer feedback control law for structural mode control of the TIFS airplane is presented. Gust alleviation techniques involving direct gust measurements and maneuver load control techniques were also developed.

*Calspan Corp., contract F33615-73-C-3051.

427 *Weber, J. A.: **Splined Version of FLEXSTAB — A Critical Analysis of Alternate Schemes.** NASA CR-152030, 1977. (N78-10027)

Recommendations are made for improved aerodynamic models and numerical schemes to be considered for inclusion into the FLEXSTAB computer program system. These recommendations are based on a critical analysis of numerical technology.

*Boeing Commercial Airplane Co., contract NAS2-7729.

428 *Weingarten, Norman C.: **An Investigation of Low Speed Lateral Acceleration Characteristics of Supersonic Cruise Transports Utilizing the Total In-Flight Simulator (TIFS).** NASA CR-159059, 1979. (X79-10159)

An investigation of the low speed lateral acceleration characteristics of advanced supersonic cruise transports was carried out in the USAF Flight Dynamics Laboratory Total In-Flight Simulator (TIFS). The magnitude and shape of the lateral acceleration experienced at the pilot position was varied by using different control laws and changing the pilot location in the simulated airplane. The lateral-directional characteristics of the Boeing 747 were also simulated for comparison purposes. The piloting tasks included up-and-away airwork and landing approach. Moving the pilot to different locations did significantly improve the pilot ratings. A wide range in the parameter $n_{y_{p_{max}}}/p_{max}$ (maximum lateral acceleration at the pilot station per maximum roll rate due to a roll step input) was obtained in this study and appears to correlate well with pilot rating.

*Calspan Corp., contract F33615-78-C-3602.

429 *Yen, Wen-Yo; and Swaim, Robert L.: **Effects of Dynamic Aeroelasticity on Handling Qualities and Pilot Rating.** NASA CR-155339, 1977. (N78-13070)

Pilot performance parameters, such as pilot ratings, tracking errors, and pilot comments were determined for a longitudinal pitch tracking task using a large, flexible bomber with parametric variations in the undamped natural frequencies of the two lowest frequency symmetric elastic modes. This pitch tracking task was programmed on a fixed base simulator with an electronic attitude-director display of pitch command, pitch angle, and pitch error. Low frequency structural flexibility significantly affects the handling qualities and pilot ratings in the task evaluated.

*Purdue Univ., Grant NSG-4003.

Articles, Meeting Papers, and Company Reports

430 Ball, J. N.: **Rolling Tail Design and Behavior as Affected by Actuator Hinge Moment Limits.** AIAA Paper 78-1500, Aug. 1978. (A78-47940)

431 Grantham, William D.; and Nguyen, Luat T.: **Recent Ground-Based and In-Flight Simulator Studies of Low-Speed Handling Characteristics of Supersonic Cruise Transport Aircraft.** AIAA Paper 77-1144, Aug. 1977. (A77-43174)

432 Kurzhals, P. R.; and Deloach, R.: **Integrity in Flight Control Systems.** Proceedings of Joint Automatic Control Conference — Volume 1, Inst. Electr. & Electron. Eng., 1977, pp. 489-497. (In A78-23851)

433 Nissim, E.: **Comparative Study Between Two Different Active Flutter Suppression Systems.** J. Aircr., vol. 15, no. 12, Dec. 1978, pp. 843-848.

434 Reynolds, Philip A.; and Hall, G. Warren: **Flight Simulation — A Vital and Expanding Technology in Aircraft Development.** AIAA Paper 78-337, Feb. 1978. (A78-29295)

435 Rickard, W. W.: **Modeling and Parameter Uncertainties for Aircraft Flight Control System Design.** AIAA Paper 78-1371, Aug. 1978. (A78-46558)

436 Rynaski, E. G.: **Gust Alleviation — Criteria and Control Laws.** AIAA Paper 79-1676, Aug. 1979. (A79-45340)

437 Rynaski, E. G.; Andrisani, D., II; and Eulrich, B. J.: **Gust Alleviation Using Direct Turbulence Measurements.** AIAA Paper 79-1674, Aug. 1979. (A79-45339)

438 Rynaski, Edmund G.; Andrisani, Dominick, II; and Weingarten, Norman C.: **Identification of the Stability Parameters of an Aeroelastic Airplane.**

Technical Papers — AIAA Atmospheric Flight Mechanics Conference, Aug. 1978, pp. 20-27. (In A78-46526)

Available as AIAA Paper 78-1328. (A78-46528)

439 Swaim, Robert L.: **Ride Quality Flight Testing.** J. Guid. & *Control*, vol. 1, no. 2, Mar.—Apr. 1978, pp. 159-160.

440 Swaim, Robert L.; and Yen, Wen-Yo: **Effects of Dynamic Aeroelasticity on Handling Qualities and Pilot Rating.** AIAA Paper 78-1365, Aug. 1978. (A78-46554)

441 Taylor, L. W., Jr.: **Active Controls for Transports.** Aviat. Eng. & Maint., vol. 1, Oct. 1977, pp. 7-10.

AUTHORS INDEX

INDEX OF NASA REPORT NUMBERS

Entry

NASA Contractor Reports